THE COMPUTER BULLETIN

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Items of interest to members, announcements by users and manufacturers, and notes of Specialist or Regional, Group or Branch activities should be sent to the Editors, The Computer Bulletin, British Computer Society, 29 Bury Street, St. James's, London, S.W.1.

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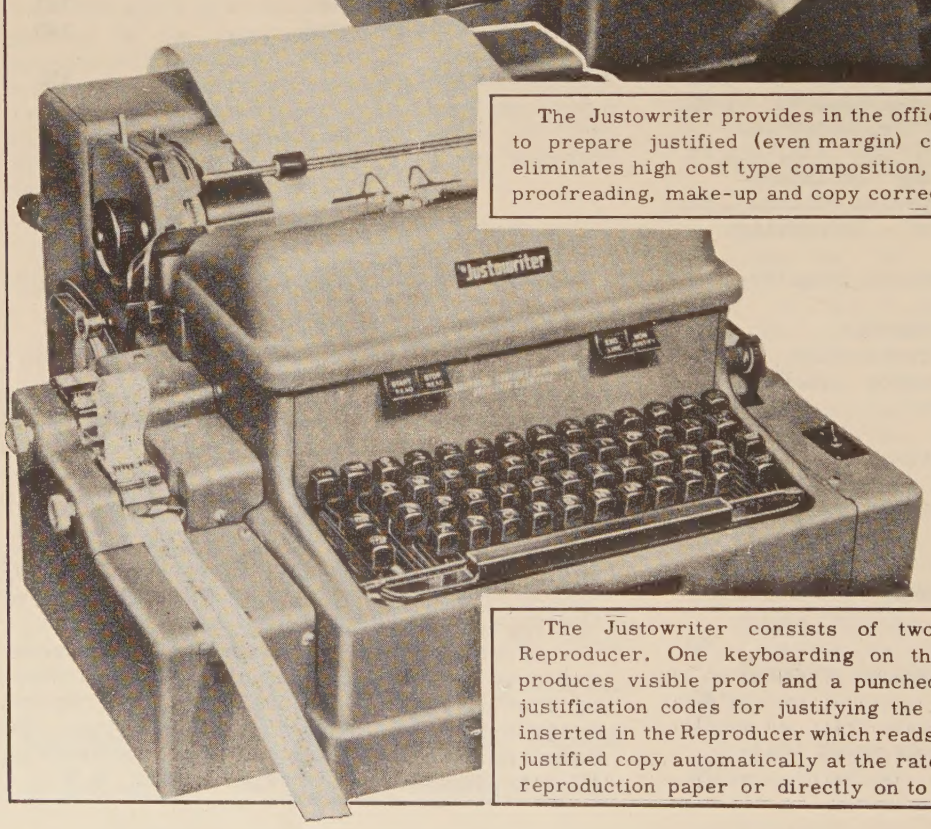

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LONDON COMPUTER GROUP

STUDY GROUP REPORTS

1956/57 SESSION

PREFACE

During the winter session of 1956/57, twenty-four Study Groups of the London Computer Group met at regular intervals to exchange information and experience on the development and use of computer equipment.

The field was divided into ten subjects and, in most of the subjects, two or more Study Groups were formed. Although, as has been said, the primary object was to provide a forum for discussion, the Reports and conclusions reached by the Study Groups are considered to be sufficiently interesting to merit publication.

Where Study Groups working in the same subject have come to broadly similar conclusions, their Reports have been consolidated into one. In some cases, however the Reports have been published separately to throw up significant differences in opinion and in approach.

The Groups considered the problem from the point of view of commercial work and the conclusions drawn are, therefore, applicable only in this field and in many cases reflect the specific professional or business occupations of the individual members of a Study Group.

THE REPORTS REPRESENT THE MAJORITY OPINION IN EACH STUDY GROUP BUT DO NOT OF COURSE NECESSARILY REPRESENT THE VIEW OF THE BRITISH COMPUTER SOCIETY, ITS COUNCIL, THE LONDON COMPUTER GROUP, ANY COMMITTEE OR INDIVIDUAL MEMBER.

In so far as references are made to the equipment of particular manufacturers, the manufacturers concerned have seen Reports 9 and 10 prior to publication and their co-operation is gratefully acknowledged. The remaining Reports remain as far as possible in the words and style of their authors with the minimum of editing.

I - ADMINISTRATIVE & FINANCIAL CONSIDERATIONS AFFECTING COMPUTER INSTALLATIONS

The discussions and findings of the two groups studying this subject were very similar. The two reports have, therefore, been consolidated into one.

METHOD OF APPROACH

1 The subject was considered under the following headings -

(a) Essential factors to be considered by Management.
(b) How best to ascertain the practicability of a computer application.
(c) The form and contents of the Panel Report.
(d) What considerations Management should apply to the Report of the Panel.
(e) The financial considerations involved after deciding whether the whole or only part of the Panel's report be adopted.

GENERAL COMMENTS AND CONCLUSIONS REACHED

Essential factors to be considered by Management

2 Although no general rules can be stated, it is suggested that the following comments will be of assistance.

3 It is essential that Management should be enthusiastically in favour of investigating the application of electronic methods and be prepared to issue the necessary directives and to foster staff education.

4 Management should be aware of the enormous possibilities of integrated data processing and should appreciate the effects an electronic installation could have on an organisation. This could necessitate reorganisation involving changes in functional activities of departments, the latter having to be knit together much more closely.

5 Management should review critically the information it receives and reorganise this so that it receives details of only those items on which decision or action has to be taken. It should also bear in mind the kind of information which a computer could produce and the time at which it could be produced, so that by gradual expansion of the reorganisation Management would obtain the information it desired but which could not be provided otherwise.

6 In addition to financial considerations, thought should also be given to the size and kind of computer to be installed. Should the size be sufficient to enable very considerable expansion to take place over a period of years (thus permitting experimental work), or would it be more advantageous in view of the rapid developments in electronic equipment to instal a smaller computer (e.g. a computer working on punched cards particularly where a punched card system already existed) ?

How best to ascertain the practicability of a Computer installation

7 Here again, no fixed rules can be enunciated since the question is dependent upon the type of trade and size of organisation.

8 The first step is the appointment by the Board, or by an official at Management level, of a member of the organisation who has a good general knowledge of the business to consider whether there is, in fact, any possibility of electronic application by reason of

(a) volume of detail involved,
(b) the difficulty of obtaining staff and premises,
(c) greater efficiency and service to Management and customers, and
(d) the possibility of producing information which cannot be obtained or can only be obtained uneconomically under present methods.

9 If it is not possible to allocate a member to perform the above work, the appointment of an outside consultant should be considered.

10 This member or outside consultant would make his recommendation and the Board would then authorise the appointment of a panel of executives to investigate the proposed application(s).

11 The membership of the Panel would depend upon the size and nature of the organisation concerned, but generally the following should be included -

(a) The original member appointed by the Board,
(b) The Chief Accountant or his representative,
(c) The Production and Sales Managers,
(d) The heads of other Departments when the work of their Departments is being discussed,
(e) A member having experience in Organisation and Methods.

Terms of reference are desirable, but they should be broad and more for the purpose of giving the team authority than for setting limits to their activities.

Upon the findings of this Panel the Board would make its final decision whether or not to proceed.

The Form and Contents of the Panel Report

12 The Report should cover the effect of a computer installation on all aspects of the organisation's activities.

13 The following broad heads of the Report are indicated -

(a) Simplified description of work to be covered supported by simple flow charts.

(b) Statement of the advantages of producing existing information more efficiently, cheaply and accurately and of producing information hitherto unobtainable or only obtainable uneconomically.

Speedier production of existing information and the integration of data processing should result in -

(i) better planning of activities,

(ii) shorter reports due to the selection, electronically, of action statistics,

(iii) reductions in staff, and

(iv) the production of hitherto unobtainable information developing new techniques at higher management level (e.g., market research, budgets, forecasts, etc.) thus providing greater opportunites for preplanning.

(c) Comparisons of costs with those of existing systems.

Comparative costs of the computer installation based on computer time and full cost (written off over the life usually attributed to office equipment) should be shown together with a clear statement of the percentage capacity of the computer utilised. The full cost comparison would probably not show up as economic when compared with the existing costs, but the value of the additional information obtained, or the value of further applications, could then be more easily assessed on the basis of covering the loss shown on the suggested applications.

The costs should, of course, include -

(i) a proportion of the costs of preparing files of prepunched cards, standard tapes, initial programming, etc.,

(ii) continuing costs (e.g. further programming, maintenance, etc.), and

(iii) staff control and supervision costs, etc.

(d) Estimate of the probable time to be taken to implement the suggested scheme and the phasing thereof.

(e) Indications as to the possibility and practicability of centralised record keeping.

(f) Appraisal of the effects of electronic data processing on functional activities.

The changes in functional activities would be governed by the degree of existing organisation, and the amount of integration possible. This again would depend upon the size of computer to be installed.

The effects on functional activities would be to -

(i) reduce the amount of clerical work, both by Departmental Heads and by Shop Clerks, leading to greater efficiency in Production Departments;

(ii) concentrate more on standard lines by the elimination of special products and their raw materials: this would follow from the recommendations of the Panel, who would have examined the effects of the volumes of speciality products during their investigations;

(iii) enable despatch centres to give quicker deliveries and the Accounts Section to provide more accurate invoicing to customers;

(iv) enable Cost Office to provide more accurate costings;

(v) centralise record keeping, thus reducing staff and giving a greater variety of work;

(vi) expand the interest of clerks in the work due to the reduction in pure routine;

(vii) create a greater team spirit due to the necessity for each member of a section to be able to handle more than one class of work in order to maintain the flow of information to the computer;

(viii) enable new skills to be acquired;

(ix) co-ordinate planning.

These effects on functional activities would necessitate the revision of organisational charts, transfers of staff between Departments, proposals for the employment of otherwise redundant staff, and the engagement of more mature clerical assistance due to the importance of the accuracy of original data preparation.

(g) Suggestions as to the planning of further detailed investigation and reorganisation, if the computer project were approved.

(h) Considerations as to the siting and building of a new location to house the equipment should this be felt necessary.

What considerations Management should apply to the Report of the Panel

14 The following broad heads are put forward for consideration but time has precluded conclusions being reached during the current session -

(a) How to assess whether the value of new information would make the whole project economic.

(b) Whether the major changes in functional activities are acceptable and, if so, how to implement them.

(c) Bearing in mind that a computer could only give results from the information presented to it, to what extent should it control the activities of

an organisation.
(d) How to ensure that action would be taken on the information supplied by the computer.
(e) What would be the policy towards displaced and redundant staff.
(f) If it were agreed to proceed, how would the further detailed investigation and reorganisation be planned.
(g) Would the Panel's suggestions for expansion be acceptable. If so, should centralisation be considered - would this be desirable.

2 - THE IMPACT OF ELECTRONIC DATA PROCESSING ON MANAGEMENT CONTROL AND ADMINISTRATIVE ORGANISATION

Three Groups studied this subject; their reports are given separately.

REPORT 2A

DEFINITION OF SUBJECT

1 It is not possible to provide a single definition of the subject which will adequately represent the interests of all industries or organisations. Therefore a somewhat different approach to the definition of the subject may prove more profitable.

2 The management of a concern has functions which can be classified in a number of well-defined groups. These elements of management responsibility can be studied separately and the impact of EDP on each aspect of management can be studied individually. As a result of these studies, it should be possible to determine the general form of the administrative changes which will be involved in implementation of integrated electronic data processing within a concern. The subject, defined retrospectively, can be summarised as

"The effect of electronic data processing on the attitudes and responsibilities of management; the changes in organisational structure and administration entailed; and the guidance, co-ordination and supervision of the personnel involved".

METHOD OF APPROACH

3 Papers on the following subjects were prepared by individual members of the group and used as a basis for discussion -

(a) a general appreciation of the impact of computers and automation on management;
(b) control of sales and distribution;
(c) management control of finance;
(d) research;
(e) organisation.

4 These papers, and the discussions subsequently held, revealed a number of basic problems which will arise from the introduction of EDP.

EFFECT ON TOP MANAGEMENT

5 Management must first understand something of the techniques of EDP and accept their implications. In particular, greater use must be made of the principle of management by exception. This factor continually emerged in discussion.

6 By the use of EDP management decisions can be based on fuller and more up-to-date information. Integrated EDP will make constant review of the organisational structure by top management essential.

EFFECT ON MANAGEMENT RESPONSIBILITY

7 Almost certainly there will be a reduction in the number of management steps.

8 Management must know what data is available and how to use and ask for it. The data processing will probably be centralised, hence the departmental manager must think beyond his own department.

9 Because those at the lower levels of responsibility will now be better informed, their responsibility might in fact be increased.

10 The setting of the limits used in exception techniques is a management responsibility and the present use of these techniques varies considerably with the nature of the undertaking.

11 In some organisations, however, management continue to employ some intuition and what passed for intuition might, in fact, be the subconcious absorption of background information. On the introduction of EDP this background may be provided by the presentation to management of additional data (chosen by management) along with the exceptions. The present

acquisition of this intuition by management is a lengthy and rather haphazard process and the data produced by EDP will probably result in distribution of more accurate background information to a wider range of management personnel.

EFFECT ON ORGANISATIONAL STRUCTURE AND ADMINISTRATION

Organisational Changes

12 The Data Processing Group should act as a service to the rest of the organisation. Because the computer allows the dissemination of large quantities of data throughout the organisation, communications within the organisation will, in effect, be shortened and lateral communications should be strengthened. This will affect the conventional line and staff structure found in most organisations and a ring structure may emerge, with management at the centre of the ring advised by the Data Processing Group.

Preliminary Investigation

13 There should be a steering committee to investigate the application of EDP and this should be of managerial status. The advantage to be expected from the installation should be in the production of more complete information, rather than in a large saving of staff.

14 There are two possible approaches to the examination of the clerical system before the introduction of the computer: either

(a) to devote the main effort towards the preparation of individual applications for computer operation (later the converted systems could be improved to utilise the capabilities of EDP more fully), or

(b) to prepare and develop final, well integrated systems before delivery of the computer, and to utilise its capabilities fully from the start.

Opinion on which of these methods should be adopted varies, and probably depends finally on the nature of the industry or organisation.

Speed and Detail of Data Production

15 One of the major advantages of EDP is the rapid production of data, but this can only be realised if the unprocessed data is in a form to permit rapid input into the computer. This implies that all data must be reducible to a numerical basis. There is also a major problem in checking the accuracy of the input; this can best be done at the place where the data originates.

16 Whilst the computer programme should cater for all exceptions likely to occur in practice, it might be expedient on some occasions to remove some exceptions for separate processing where this will give rise to a more rapid result.

Programming

17 The staff to study the applications and prepare detailed reports should comprise systems investigators to determine procedures and prepare flow diagrams, and encoders to write the required instructions in machine language from the flow diagrams, together with at least one member from each department concerned.

EFFECT ON PERSONNEL

18 One of the major problems to be faced in the introduction of EDP is the simultaneous disruption of all the social groups which form in a large clerical organisation. Lengthy preparation may be necessary to deal with this problem. Information about the project must be given to all levels as early as possible. In fact, something in the nature of a crusade is required.

19 There is at present insufficient data to decide what changes there would be in the number and distribution of grades of personnel, and opinion is divided on the percentage of the present work which a computer might be expected to take over and on the possible extent of redundancy.

20 It is desirable to switch personnel of equal standing between departments in the organisation, to broaden their outlook.

REPORT 2B

METHOD OF APPROACH

1. The subject was approached under the following heads -

(a) What is management?

(b) What does management need?

(c) How can EDP assist in satisfying the needs of management?

(d) What will be the effect of EDP on administrative organisation?

DEFINITION OF MANAGEMENT

2 Some time was spent at first in defining the term management, although it was appreciated that the first definition might have to be modified later.

3. During subsequent discussions, however, the importance of having a precise definition dimished as the term and its meaning was never in dispute.

4 The agreed definition was 'That "Management" for the purposes of this study shall be deemed to comprise those members of an organisation responsible for the formulation and execution of policy within that organisation.'

NEEDS OF MANAGEMENT

Education of Management

5 It is important to distinguish between what management wants and what it needs. It is feared that because of the speed and facilities of a computer, management might ask for information without proper regard for its value and the cost of producing it.

6 Demands for ad hoc information not produced as part of the standard routines may require the retention of a large volume of primary and intermediate data. On magnetic tape, for example, this can be expensive. Casual information which may be obtained just for the asking from a manual system, and which has therefore been taken for granted in the past, might be obtainable only after laborious and costly process through the computer unless properly planned before installation.

7 There is, therefore, a need for management to learn something of the capabilities and limitations of EDP before they are asked to state their requirements. Only in this way may best use be made of the machines in the long run. The task of educating management will be undertaken to a small extent by the manufacturers of the machines, but will need to be carried much further by the team planning the installation.

Information to Management

8 The volume of data supplied to management can be reduced by, for example, reporting only those items which vary by more than a certain tolerance from the standard (i.e. management by exception).

9 On the other hand a computer system should be designed so as to supply any data that may be requested to provide the maximum possible information and analysisis.

Planning of Installation

10 In cases where computers are installed principally for the immediate purpose of achieving a clerical saving, as opposed to the production of information not available by manual methods, the information to management will probably be prepared in a similar manner to that before the installation and be amended later in the light of experience. One organisation in fact intends to adopt this procedure mainly to produce some early return for the expenditure on a computer.

11 It is recognised that, notwithstanding the steps taken to educate management, it may be necessary, in the early stages of operating a computer system, to preserve the original data until all reasonable chance of requiring it for re-processing has passed.

12 This may mean keeping data for a year or more. Planning to produce the major requirements of an organisation by means of a computer may well be an easy task compared with forseeing the many subsidiary requirements which will arise from time to time.

13 This approach to the subject is recognised as being contrary to the more general opinion that existing methods should be comprehensively reviewed before converting to EDP. Many firms, of course, propose installing a computer for a specific function which is giving trouble at present.

Budgetary Control

14 In most concerns management is exercised, in the broad sense, through the compilation of the budget and budgetary control. It is interesting to note, however, that in certain financial institutions (such as banks and brokers) budgetary control is NOT an instrument of management and, in the sense used in commerce and industry, is virtually unknown to them.

15 There is no doubt that electronic computers can and will be used for budgetary control purposes - the extent of this use varying with the nature of the concern. Budgetary control is not likely to be the first application to be put on a computer but will generally follow after experience has been gained on more routine processing jobs. Eventually it may well be that indirect savings arising from such an application will outweigh the direct savings obtained from pure data processing work.

HOW EDP CAN SATISFY THE NEEDS OF MANAGEMENT

16 EDP can provide a service to management on the lines indicated above but time has precluded giving detailed consideration to the features required in an installation to make this possible.

EFFECT OF EDP ON ADMINISTRATIVE ORGANISATION

Centralisation

17 The administrative problems that will be caused by centralisation where recording is at present dispersed are, broadly, the collection of data from outlying establishments and, where appropriate, distribution of the processed information (e.g. pay and pay lists).

18 For transmission of data to the computer, only the existing postal, telephone, telegraph or teleprinter services are available. The limit of development so far in this country is the transmission of data directly onto punched paper tape. It is understood that in U.S. transmission of data direct onto punched cards or paper tape is accomplished by telegraphic links or radio transmission; G.P.O. facilities in this country will not at present accommodate this form of transmission.

19 Distribution of pay could be facilitated by encouraging the extension of cheques or bank credits and, if possible, arranging for local banks to act as pay clerks.

20 It is recognised that the efficient use of electronic methods for the preparation of pay-rolls may well require alterations to existing practices regarding rates and scales and time periods of pay. Cases may occur where consultation and agreement with Trade Unions would be desirable.

Space

21 There may be a need to re-allocate office space. This should lead to an overall saving although in some cases more central accommodation will be required with a consequent surfeit of local accommodation. A certain 'diseconomy' by way of capital loss may arise.

Concentration

22 With a computer, processes previously carried out over a large area of office space will be concentrated. In one concern this has caused a problem of the speedy removal from the 'bottleneck' of the output of paper. Similar considerations may well apply to input data.

Staff

23 The majority of employees rendered redundant will be the lower ranks. It is considered however that a proportion of more senior personnel may not be required. One concern is solving this difficulty by early retirement of senior staff who cannot be absorbed elsewhere.

24 The senior staff remaining will require a wider outlook than formerly. Timetables will be more precise and therefore more exacting.

Recruitment and Training

25 Many middle management positions will cease to exist and consequently there will be a gap in the management ladder between junior employees engaged on the routine preparation of data for EDP and the senior staff fulfilling higher management functions. This being so, concerns using a computer may have to recruit higher management from the professions and from concerns not using computers.

26 It is desirable that industry and commerce should be prepared to continue and expand training schemes for (perhaps specially recruited) junior personnel and to accept and encourage movement between firms. The fact that trainees frequently leave for better positions should be accepted - just as the articled clerk is not expected to remain with his principal after qualifying.

REPORT 2C

DEFINITION OF THE SUBJECT STUDIED

1 The Group agreed the following definitions -
(a) Management Control: The maintenance, regulation and modification of the nature and level of all the activities of a business in accordance with the planned objectives of management. Management means ultimately top management, but control can only be effective if responsibility is successfully delegated to lower management levels. Management Control is one of five interrelated and indivisible functions of management which are Policy Formulation, Planning, Implementing, Co-ordinating, and Controlling.
(b) Administrative Organisation: The formal pattern of line and staff responsibilities; the interrelationships of persons exercising them; and the means of communication between them.

METHOD OF APPROACH

2 The subject has been studied by considering
(a) how EDP can provide, and has provided, management with
(i) the same information as traditional equipment, and
(ii) additional or new kinds of information not hitherto supplied,
(b) what ideal management needs, and
(c) the impact of EDP on the machinery for meeting the information requirements of management.

GENERAL COMMENTS AND CONCLUSIONS REACHED

The Impact of EDP on Management Control

3 Many, if not most, policy decisions will never be solved by a machine because of -

(a) the difficulties of programming in this field, and
(b) the continual occurrence of unforeseen contingencies (e.g. political).

Subject to these factors, however, management at all levels will get better information and quicker results. More policy decisions will be based on scientifically interpreted quantitative data than on 'hunches', and the need for ad hoc decisions will be greatly reduced.

4 There will be more decisions about criteria or limits in consequence of the greater use of operational research techniques for top management decision making, leading to more management by exception (i.e. those results which fulfil the criteria or fall within the limits will not be brought to management's notice). There is, however, an inherent danger in this method and the limits must be interpreted in the light of circumstances and not just as a routine.

5 There will be more precise stipulation of management's requirements in order to fix the criteria or limits already mentioned, and also because delegation is to a 'machine'.

6 Statistical and operational research techniques will be more widely applied especially in the fields of planning, production, and product mixes. Such techniques have been applied for many years, especially on the technical side, through the use of calculating machines - more recently analogue computers - and they will not be an innovation of electronic digital computers. Electronic digital computers, however, will permit their application to be vastly extended.

7 The means of producing control information automatically will cause a minor revolution in the accounting function. EDP will provide the industrial accountant with a much better tool than he has had so far and will supply the stimulus to a further application of budgetary control, standard costing, and regular profit statement. It will, in addition, enable him to forecast relatively short periods ahead and make rapid adjustments to pre-planned budgets. EDP will also make possible a greater control throughout the organization by the setting of standards of attainment at all levels and a quicker measurement of accomplishment. By all these means 'profit regulation' will be more effectively realized.

8 Planning will be much more scientific -
(a) Market Research: there will be a firm basis from which to start, though it is doubtful whether EDP will develop new techniques in this field where judgement of economic, political and social factors play such an important part.
(b) Production: EDP should enable the most efficient use to be made of machinery by the simulation of production schedules.
(c) Stock Levels: the more up-to-date the information regarding stock, production and orders received, the more economic it is to keep stock levels. EDP should satisfy these requirements.
(d) Capital Requirements: by the simulation of future happenings based on more accurate forecasts, EDP should make it possible to foresee the capital expenditure required.
(e) Profitability: the use of operational research techniques should enable product mixes to be made to obtain maximum profitability.

The Impact of EDP on Administrative Organization

9 Is EDP likely to increase the optimum size of undertakings? Will it result in greater or less decentralization? Such questions tend to give an incorrect picture of the real issue. The optimum size of a business is a function of the conditions of the markets in which it operates. If the analysis of the economic situation indicates that the firm's size ought to be increased, the electronic machines now available will help to make such an increase feasible. In other words, the economic analysis will decide the question of whether to install one large central computer installation or a number of smaller ones.

10 Will EDP result in a re-grouping of functional responsibilities? According to C.G. Kozmetsky and P. Kircher ('Electronic Computers and Management Control') no pattern has emerged in the United States as to where a computer section should be placed in the company organization. Various arrangements have been tried. In some companies the computer sections report to the controller, in some to the chief accountant, and in others to the heads of purchasing, production, sales, or production control; in a few cases the computer sections report directly to the president. Some large corporations have more than one section. For example, one has a section responsible to the accounting function, and another section in the production department located in a different city. Another large company has assigned to different divisions the responsibility for experimenting with different types of equipment. A large merchandising corporation has followed a similar approach, assigning different input and storage devices to different stores, where they are installed in different types of selling departments.

11 The existence of several computer sections within an organization, while offering certain experimental advantages, has already led to some internal organizational conflicts. Difficulties arise because each of the sections tend to compete in several ways (e.g., for skilled personnel in an extremely tight labour market, for the attention of top management, and so on). Each section tries to prove that its approach is best, and it is difficult for top manage-

ment to determine the degree to which each should be encouraged. Different approaches are desirable if, for example, one section is interested in clerical-cost reduction and another is primarily concerned with analysis and production control. But in many cases management finds it hard to judge these experiments because of lack of experience in dealing with this new field.

12 Conflicts often have existed in various functions anyhow. For example, animosity between accountants and production engineers over cost allocations has become almost proverbial. The integration of accounting and production in such situations leads to organizational conflicts. Where engineering needs for computation are substantial, the engineers may be able to buy their own computer. If the conflict is deep-seated, in some companies this has resulted in the purchase of two different types of computers. In other companies, where this duplication has been prevented one section usually tries to take over the other.

13 It can be anticipated, however, that in the majority of cases there will be a more closely integrated organization structure with less departmentalization, which may result in some instances in the appointment of either a 'clerical manager' responsible to the Board for the preparation of all clerical data throughout an undertaking, or of a 'computer controller' who may achieve in time Board level status.

14 Since an electronic computer cannot be effectively installed without an intense preliminary O & M investigation, it is inevitable that greater importance will be attached to the O & M function; it is possible, however, that more general appreciation of work of this kind may result in its activities being decentralized.

15 The greater application of operational research techniques and the mathematical background of EDP itself will result in the appearance of more persons with mathematical training at board level to prevent Higher Management being 'blinded by the science' of their mathematical specialists.

GENERAL

16 In discussing the impact of EDP on Management Control and Administative Organization, it must be realized that we are still at the pioneering stage and the following factors will affect the rate of progress -

(a) Technical: the extent to which such complex machinery can be mass, or at least batch, produced; the reliability of thermionic valves and magnetic recording apparatus, and the ability to develop adequate methods to deal with input in an economic manner (i.e., character recognition).
(b) Knowledge: the number of properly trained personnel for both the operation and maintenance of such equipment; the complex problems of programming and the high degree of intimate knowledge of the particular machine, and high grade of logic required for this process.
(c) Management Enterprise: the extent to which management is prepared to invest a large capital outlay in a process of unknown capabilities; the ability of management to state clearly and concisely its requirements.
(d) Management Education: the readiness with which existing managements re-adjust themselves to the new concepts of control and organization, and accept the introduction of scientific aids and unfamiliar techniques; the time-lag which must occur before a second generation of managers with a re-orientated outlook have been produced by revised executive development programmes.

3 - TRAINING COMPUTER PERSONNEL

DEFINITION OF SUBJECT STUDIED

1 The following classes of personnel have been considered -

(a) Administrative level;
(b) Systems analysers and organisation and methods staff;
(c) Programme planners and coders;
(d) Operational staff -
  (i) supervisors,
  (ii) maintenance engineers,
  (iii) machine operators, and
  (iv) clerical and control staff.

METHOD OF APPROACH

2 Firstly, it was found necessary to obtain definitions of 'Computers' and many authoritative statements on the subject were considered. No single definition was deemed to be entirely satisfactory but by this means fairly good understanding of what was under consideration was obtained.

3 Secondly, a programme of study was decided upon and the training and qualification desirable for each of the above types of personnel was discussed.

4 Thirdly, it was assumed that a policy decision to instal a Computer had been made.

GENERAL COMMENTS AND CONCLUSIONS

Administrative Level

5 For scientific work: one person not necessarily having detailed working knowledge of operations but an administrator supported by two subordinates, one subordinate having full knowledge and experience of operations, the other being of graduate type in mathematics and/or physics for research, etc.

6 For business data processing: a team whose leader could with advantage be the executive responsible for orthodox mechanisation; he must have a wide experience of accounting of the organisation, logical outlook and be a good organiser; it should be sufficient for such executives to obtain adequate general knowledge of the subject by attending executive courses, lectures, and by selective reading.

Systems Analysers or 'O & M'

7 Systems analysers must have detailed experience of the work concerned, and must be capable of analysing each job into its logical sequence of operations including the creation of flow charts. They should, in fact, be O & M officers with as much training in that class of work as possible and should also have taken a programming course on the type of machine to be used.

8 Essential qualities are considered to be
(a) a logical mind,
(b) a highly critical approach,
(c) a knowledge of the machine installation's capabilities,
(d) pertinacity, and
(e) enthusiasm.

Programme Planners and Coders

9 The essentials for this type of staff are considered to be that they should
(a) be at least of G.C.E. level,
(b) have good knowledge of the machine,
(c) be trained in programming, and
(d) be highly co-operative with the systems analysers.

10 The functions of programme planning and coding tend to be largely underestimated and in most cases these functions should be combined with that of systems analyser.

Operational Staff

Supervisors

11 Opinion on the necessary qualities for supervisors appears to be somewhat varied. No common idea of the level at which the supervisor comes into the staffing arrangement seems to exist. Similarly no firm opinion as to whether they should be male or female is apparent. Cases of first class supervisors of both sexes are known but owing to the dearth of commercial installations experience is very limited. There should be separate supervisors in a large installation for
(a) punch operators and verifiers,
(b) machine room, and
(c) control office.
These three parts of any organisation should be segregated. It is essential, however, that all should be sited adjacent to one another and that there should be the closest liaison between them.

12 Generally, a supervisor should have forceful personality, be able to control staff and be something of a 'progress chaser'. There must be sufficient breadth of outlook and experience to ensure rigid adherence to the timetable and the complete synchronisation of all facets of the work.

Maintenance Engineers

13 It is considered advisable, where the size of the installation justifies it, to employ a maintenance engineer on the staff, rather than rely entirely on manufacturers' arrangements for servicing. However, difficulties might be met in keeping a really good engineer standing by against possible breakdown and such an engineer might be difficult to satisfy. The job requires a first class man, but a first class man might not be content to be pinned to one installation on maintenance only. This post is considered to be most important and one for which the user of an installation cannot afford to do otherwise than make the best provision possible. As more and more machines come into use, manufacturers and users are likely to be competing with one another for engineers and manufacturers will certainly have to undertake any major repairs requiring factory resources.

14 This category of computer personnel is also dealt with in paragraphs 20/21 below.

Machine Operators And Minders

15 It is considered that this type of personnel should be of not less calibre than a qualified tabulator operator and must have a sufficient understanding of computer programmes. Probably a senior machine operator would prove suitable after training.

Clerical And Control Staff

16 The clerical and control staff in the computer section should be confined to operations and control

in the machining processes only, and it is considered that the offices or departments submitting data to the computer section should be responsible for its accuracy.

17 The attributes desirable in computer clerical and control staff are that they should be of the 'progress chaser' type to ensure prompt and efficient turnover of work in accordance with the requirements of the programme.

Staffing Arrangements In Existing Installations In The U.K.

18 Inquiries as to staffing and establishment at the four computer installations engaged on scientific work and providing mathematical services showed the following complements -

(a) 1 with 1st class degree in mathematics,
1 mathematics graduate, and
1 other.
(b) 1 with Ph.D. (in charge),
2 mathematics graduates, and
1 other.
(c) 3 mathematics graduates (not high level) who programme and operate, and
2 girls at Higher Certificate level.
(d) 2 mathematics graduates (medium level), and
2 girls at Higher Certificate level.

(c) and (d) were involved on the mathematics of aircraft performances, etc.

19 Briefly, the personnel mentioned remain in situ at the computer, waiting for departments to come to them with any job required. They offer their criticism and advice on the modus operandi, and work out the problem for the department or official requiring the services of the computer. The machines are small types.

Appointment Of Staff From Manufacturers Of Machines Comprising The Computer Installation

20 The following points are made relating to the maintenance engineer -

(a) Manufacturers will train a user's own engineer in the servicing and maintenance of the computer;
(b) The qualification required in a maintenance engineer before he is trained in computer technique should be of not less standard than the Higher National Certificate in Engineering with mathematics and electronics;
(c) Whether the installation is held on a rental basis or has been purchased outright, a commercial user is best served by availing himself of the computer manufacturer's servicing arrangements. Under no circumstances should a commercial user have to rely upon one engineer as the day would surely arrive when a fault would occur beyond his capacity. In the case of a computer being used for scientific, research or mathematical purposes, the user often has his own engineers available who could have been trained to service the machine satisfactorily themselves and would in any event always be available for consultation.

21 It is unlikely that permanent staff other than engineers will be drawn from manufacturers.

Establishments Required For Various Sizes Of Installations

22 The size of an establishment depends entirely on the application to which the computer is being put and it is not possible to give any generalised statement on the establishment necessary for an 'average installation'.

Control Of Initial Data And Control Of Personnel

23 It is of the utmost importance that initial and preparatory work on data should be under tight control. To this end it is also important that sections, departments, etc., who provide initial information should be kept fully in the picture as to the objects and methods adopted for the computing processes.

24 To obtain the best and most economic benefits from a computer it is essential to work on a very tight timing schedule. Sections responsible for 'feeding' the installation must be fully conversant with the timing programme and ensure that the data for which they are responsible is supplied to the Computer Section exactly at the pre-arranged time.

4 - GENERAL ACCOUNTING

DEFINITION OF THE PROBLEM

1 The problem is to determine what conditions are required to be able to apply electronic computers to the general accounting functions of a business and at what cost.

APPROACH

2 The Study Group approached the problem as follows -

(a) The problem should be approached on a broad general basis applicable to all undertakings as the principles will be common to all and the extent to which information is required is a matter of detail.

(b) The precise form in which information will be required depends on the particular Management, but the following definition of 'information' may be applied -

"The presentation of figures for a given period, together with a statement of variants supported by the appropriate historical data, in sufficient detail to indicate trends."

The requirements of Management should be integrated with accounting processes.

(c) The problem should be broken down into Component Parts and the application of coding principles to the particular accounts should provide the necessary analysis.

The Component Parts are suggested as follows -

(i) SALES AND OTHER INCOME
- Cash
- Credit
- Contract
- Miscellaneous Sources

(ii) EXPENDITURE
- Consumption of Materials
  - Purchases
  - Stores Control
  - Work in Progress
  - Finished Goods
  - Packages and Containers
- Manufacturing Expenses
  - Depreciation of Fixed Assets
  - Other Manufacturing Expenses
- Trading Expenses
- Administrative Expenses
  - Remuneration
  - Overheads
  - Other Expenses
- Selling and Distributive Costs
- Capital and Finance Charges

(iii) CAPITAL REALISATIONS AND EXPENDITURE

(iv) ASSET GROUPINGS
- Fixed Assets
- Current Assets - by due date
- Intangible Assets

(v) LIABILITY GROUPINGS
- Fixed Liabilities
- Current Liabilities - by due date
- Provisions

Budgetary Control

3 It is suggested that the starting point should be the Budget and the production of information should provide for comparison with the Budget for the period involved.

Recording Media

4 While punched cards may form the best media for input data for Final Accounts in view of the need to provide historical data, the developments in the use of tape show there are, even now, no technical difficulties in selective reading from tape.

Input Data

5 The form of input data and the source and style of originating documents cannot be standardised but must be varied over classes of data.

6 For data in respect of which no originating documents are normally available, the Accountant will initiate the advice to the Computer. It will be necessary to ensure that apportionments are dealt with where appropriate and the possibility of including instructions for this in the Machine Programme will be considered when this aspect of the problem is surveyed.

7 Input Data falls into three basic headings -

(a) Sales and Other Income,

(b) Revenue Expenditure, and

(c) Capital Realisations and Expenditure.

8 Balance Sheet (Asset and Liability) Groupings which do not arise out of Journal or Cash Entries should fall out naturally, according to the coding and classification system used, when the Trial Balance is run off.

Output

9 A form of output can be envisaged as a four-column Trial Balance -

(a) Expenses - items lost before profit is produced,

(b) Turnover - with an appropriate analysis,
(c) Assets - Fixed, Current, etc., and
(d) Capital - including Reserves and Provisions.

10 It will thus be necessary to deal with 'double entry' and totals would have to be stored to provide the 'other side' of the transaction for accounting purposes.

11 In addition, the output should provide for historical and statistical data - but the extent to which this would be required is a matter for individual managements.

GENERAL IMPLICATIONS

12 The following are considered in appendices -

	Appendix
Coding Requirements	1
Audit Requirements	2
Legal and Taxation Requirements	3
Speed of Producing Information	4
Availability of Information for Special Studies	5
Length of Accounting Period	6
Forms Layout Requirements	7

DETAILED REQUIREMENTS

13 The Study Group examined in some detail Accounts Payable and Property Record requirements. Examples of such requirements are included in this report in the following appendices -

	Appendix
Accounts Payable (Flow Chart)	8
Property Records	9

CONCLUSIONS

14 In view of the wide range of activity covered by the heading 'General Accounting' and the many variations which are imposed by product considerations, it is felt that this report should only be treated as an interim document and that there is still a wide field for further study.

Appendix 1

CODING REQUIREMENTS

1 The advent of Electronic Data Processing equipment for accounting and general office procedures requires, as a prime necessity, a logical coding system as being the only means by which information can be fed to the Computer.

2 Coding systems, for various purposes, have been in existence since ancient times, but their development for accounting and statistical purposes dates back to the introduction of Punched Card equipment.

3 If a computer is to be an economic proposition for accounting purposes it is essential that the data to be processed shall be prepared with the utmost speed and accuracy and to this end considerable attention must be given to the compilation of the accountancy code.

4 The code must be planned as a whole. Other Study Groups concerned with salaries and wages procedures, and stores accounting, etc., will of necessity have to prepare a coding system for their specific requirements, but the ultimate responsibility must remain with those responsible for the final accounts. Any subsidiary code, therefore, should be so designed that control totals can be automatically incorporated in the final accounts without undue recoding.

5 In preparing a coding system it should be borne in mind that because much of the input data for the computer will be prepared by junior and sometimes non-clerical staff it should be readily understandable.

6 The number of digits used in compiling the code should be within limits consistent with all the accountancy requirements allowing for the inclusion of additions and amendments as required. A suggested format might be Main Head/Sub-Head/Analysis/Division. As far as possible the sub-head and analysis codes should have the same interpretation irrespective of the main head. The division part of the code would be used for costing over departments, branches, agencies, etc., all using the same main head, sub-head, and analysis for accounting purposes.

7 Much coding is of a repetitive nature and should therefore be reduced to a minimum by mechanical aids so far as the clerical function is concerned.

8 Punching of the input data should, as far as possible, be from original documents and the layout of the coding blocks should be such as to reduce to a minimum the clerical function, and also be so positioned that the operators can quickly read the data.

9 Finally, it should be noted that it is possible to cover by one code all the accounting requirements of an organisation up to and including the Final Accounts and Balance Sheet - the only necessity being a separate main head for the Balance Sheet with appropriate sub-heads and analyses for Assets and Liabilities.

Appendix 2

AUDIT REQUIREMENTS

1 Any major change in the system of recording the financial transactions of a concern will require to be discussed with the auditors during the planning stage, so that the audit can continue to be conducted to the satisfaction of both parties and without any increase in cost. In order to obtain some idea of the matters which will come under consideration, it will be useful to examine the main tasks involved in the audit.

2 In general, the auditor must obtain sufficient information to be able to give the owners of the concern an assurance (similar to that given to the shareholders of a company) that proper books of account have been kept, and that the accounts signed by him agree with the books and give a true and fair view of the transactions and state of affairs of the concern. There will, in addition, be special requirements for some types of concern (e.g. local authorities). The auditor will also need to satisfy himself that the systems in force minimise the chance of loss by fraud or error as far as is consistent with economy of working: that the internal check is satisfactory. These objects are achieved by first acquiring a knowledge of the systems in use by the concern for carrying out and recording its transactions, and then by making tests of the records. The extent of these tests will depend partly on the efficiency of the internal check.

3 In a computer application to any accounting process, the first requirement for a good system of internal check will be for the programming and operating staff to have no responsibility for the day-to-day transactions of the concern. Then, it should be possible for a responsible member of the accounting staff, or of the internal audit, if there is one, to acquire a knowledge of the computer in use and of its programming routines sufficient for him to be able to appreciate both the built-in checks, applied automatically within the equipment, and the possibility of programmed checks, and to be available to ensure that the programs produced satisfy requirements in this direction. He will also want to ensure that other aspects of the work are adequately controlled, such as the authorisation and verification of input, the safeguarding and identification of programs in use, and the control over master files.

4 When the auditor has been able to assess the efficiency of the internal check, he will consider the method to be adopted to test the recording. The ease with which he can do this directly may depend on the degree of continuity of the printed results available. Where each transaction is printed out on a form of ledger sheet with identifying date and code, checking may be straightforward, but where any of the intermediate records are "lost" within the computer, the co-operation of the officials of the Concern may be necessary to enable the audit to be conducted efficiently with a reasonable expenditure of time. In particular, it may be expedient to assist the auditor in such ways as -

(a) the allocation of some computer time to audit tests of the operation of the programs on specially prepared data of which the results have been calculated by other means, or

(b) by arranging for some results to be specially printed out at an intermediate stage of the computer calculation, for comparison with the results obtained by independent calculation.

Appendix 3a

LEGAL REQUIREMENTS

1 The exact legal requirements relating to accounts will depend on the type of concern under consideration but it is thought that a statement of those relating to companies registered under the companies Act will cover a large number of the concerns interested in this aspect of computer application.

2 The Companies Act itself and relevant legal decisions should, of course, be referred to, but the broad requirements are that proper books of account shall be kept, recording purchases and sales of goods, assets and liabilities, and daily receipts and payments of cash sufficient to give a true and fair view of the Company's affairs and to explain its transactions. In addition, there are detailed provisions in the Eighth Schedule to the Companies Act, and in various sections (e.g., as to directors' remuneration) which will continue to require consideration when the re-coding of accounts is being planned for a computer application. Accounts may be kept in bound books or in any other manner, providing that adequate precautions are taken to guard against falsification and to facilitate its discovery.

3 The legal minimum of accounting records will, in normal circumstances, be completely provided by the accounting system planned for the practical running of the business and compliance with the Eighth Schedule, etc. Normal management considerations will also ensure that the systems in use provide for automatic checks on the accuracy of the recording, and that the proper division of duties between members of the staff gives reasonable safeguards against the irregular action of an employee. These aspects are also the concern of the auditors and are dealt with more fully under the heading of 'Audit Requirements'.

Appendix 3b

TAXATION REQUIREMENTS

1 The information required by the Revenue will make no special demands of the computer program except that special analyses will be required for certain types of expense (e.g., legal charges) and, in some cases, an itemised print-out of an account may be desirable. Where the need for these is known in advance, they can be allowed for in the coding of input and in the program, to cater for a possible request for an analysis or a print-out of an account normally accepted in total. The same considerations will apply as for the information requirements within the concern itself: that is, details must be held on file (i.e. tape or punched cards) for all headings which might reasonably be the subject of such a requirement.

2 There is however, one aspect of taxation requirements in which a computer could be of some assistance. This is in the calculation of the written down value of assets disposed of, in order to ascertain balancing allowances and balancing charges, which may require a series of calculations in which various rates or capital allowances are applied to the reducing value of the assets over the years they have been held.

Appendix 4

SPEED OF PRODUCING INFORMATION

1 It is accepted as a general proposition in computer studies that end results will be obtainable more speedily by the use of a computer because of the extremely high speeds at which the computer operates. Since this is a general statement subject to certain limitations, it must be stated that the speed of the work done is a function of the capacity of the computer.

2 In scientific work the amount of calculation to be done is large, whilst the amount of sorting is relatively small. In general commercial work the opposite is the case, the same type of calculation being consistently repeated on a succession of items. It can therefore be said that speed of working is to a great extent dependent on the amount of sorting of the items to be posted. The greater the number of sorting operations, the greater must be the number of storage tapes, in order to avoid re-runs when sorting on a number of different factors.

3 Finally, assuming these sorting problems have been successfully overcome, the programming operations must be arranged so as to obtain the maximum time saving at each stage. The more the intermediate operations can be 'telescoped' by deriving end results from the same set of primary data, the greater will be the speed at which the end results can be obtained.

Appendix 5

AVAILABILITY OF INFORMATION FOR SPECIAL STUDIES

1 Ready availability of information for Special Studies will depend on

(a) the type of permanent storage employed (where information is held in the form of punched cards no special problem will arise in meeting requests for ad hoc exercises), and

(b) the peripheral equipment available in the computer installation (if a magnetic tape or punched tape to card converter is available the required information can be put into the form of punched cards and be processed by orthodox punched card methods).

2 Where information is not stored in punched cards and where no tape-to-card converter is available, information could normally be extracted by a simple search routine. A problem would arise at this point if it were necessary to process the information further in order to present the answer in some required form. The difficulties could be mitigated to some extent by maintaining a library of sub-routines. Recently studies have been undertaken in the United States and in this country to simplify computer programming by techniques described as 'Automatic Programming', which would enable instructions to be given to the machine in plain language terms and to be converted by the computer into the normal program form. This should considerably reduce the time taken to produce a new program designed to process the extracted information in the desired manner. It cannot be envisaged in general, however, that requests for special studies could be met as quickly as similar requests to a punched card installation.

3 It is, of course, apparent that any such request could be met only if all the relevant information (e.g., codes) were stored either in the computer or in some form of external storage.

Appendix 6

LENGTH OF ACCOUNTING PERIOD

1 The conventional method of preparing accounts by calendar month is still popular. For purposes of comparison, however, a period of four weeks may be preferable - the accumulation of thirteen such periods forming a year's accounts. This might also suit a computer.

Appendix 7

FORMS LAY-OUT REQUIREMENTS

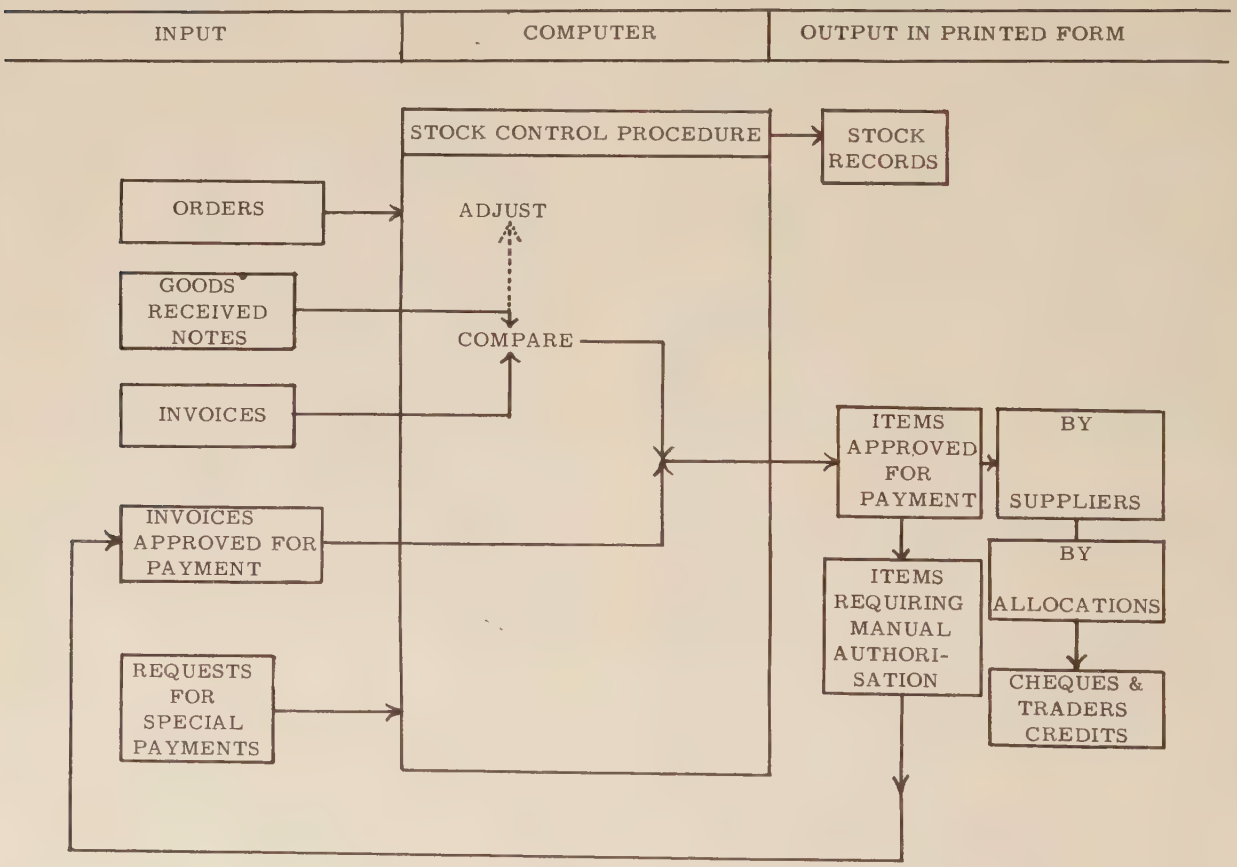
1 It is realised that in many cases computer input will originate in an automatic form such as punched paper tape produced from an accounting machine.

2 As in present punched card systems, it will be essential to design forms so as to make obvious what is to be punched into cards or paper tape, and to arrange it in the same sequence as is required for punching. This is particularly important in punching paper tape as this does not reveal upon itself the identity of information fields as can punch cards. The sequence of information should be such that skipping of fields on a punched card, or punching of skipping symbols on punched paper tape, is minimised.

3 In regard to the output on to forms of information from the computer, the layout will depend on the purpose of the form. An invoice to a customer will probably remain for sometime in a preprinted form, whereas internal documents may move more and more to the listing of significant information on plain stationery where the key to the type of information is by symbols printed by the computer and not by the printed headings in which the information falls.

Appendix 8

ACCOUNTS PAYABLE



Appendix 9

COMPUTER APPLICATION TO PROPERTY RECORDS AND CAPITAL BUDGETS

Budgetary Control of Capital Expenditure

1 Budget Projects having been established on a six monthly or yearly basis each Project is given an Authorisation No. which is then coded into individual commitments and expenditures. At selected intervals, presumably the normal monthly or other accounting period, the computer would be programmed to select commitments and expenditure, commitments being compared with corresponding expenditure and adjusted to equalise.

2 Each successive period would then be updated to produce an analysis of cumulative commitments and expenditures with balances available against each authorisation. By extracting expenditures against commitments a short term plan of financial resources required can be established, as well as a run down of the overall Budget Plan. At the same time the programme can be arranged to extract Authorisation Nos. over (say) 80% committed, for special review to establish the need for Overrun Authorisations being added to the individual Projects within the Budget Plan.

3 Individual Authorisations can be closed out on completion of transfer to Asset Accounts and any amounts not taken up by expenditure set off against overruns as a continuous check of the overall amount budgeted.

Property Records

4 The purpose of maintaining records of individual assets may, according to the nature of the organisation, be to provide any or all of the following information -

(a) Value for Balance Sheet Summary (at original cost);
(b) Value for Insurance purposes;
(c) Value for distributing Depreciation Charges in Departmental Oncost Rates;
(d) Identification for Maintenance and Renewal Schedules;
(e) Identification for Obsolescence Cost on Replacement.

5 In order to produce this information a master register would require to be set up, either by conversion from existing records maintained manually, or through an inventory taken for the purpose, consisting of coded data for each item as follows -

(a) Equipment No.;
(b) Account No. (main and sub-code by type);
(c) Location;
(d) Department;
(e) Date of Purchase;
(f) Vendor or Invoice Reference;
(g) Cost;
(h) Depreciation Rate;
(i) Monthly Depreciation Charge;
(j) Maintenance Class.

6 In so far as possible coding should be consolidated (e.g., the equipment number may identify the Department or Maintenance Class, such as a prefix 1, 2, etc., to distinguish main type of machines (presses, drills etc.), followed by serial numbers for each piece of equipment within each class).

7 Once the initial record is established, additions would be inserted from the close out record of capital Authorisations and retirements extracted from Obsolescence or Replacement Schedules. Similarly transfers can be effected between classifications of assets.

8 In a computer using punched card input the record is most conveniently held in a file of interpreted punched cards which can be pre-sorted and fed into the computer as required. Otherwise the record would be stored on magnetic tape and run at periodical intervals with current data to bring up to date.

9 For equipment involving detailed specifications, original vendors' invoices and specifications might be recorded on microfilm and stored in Safe files for permanent reference, in association with the Property Register.

Consolidation

10 Thus a complete reference to Property Records, integrated to both the financial records and Budget Plan, so as to be available for periodical review or special study when required, can be maintained in only a fraction of the space which would be required to perform the same function by manually operated methods.

5 - PAYROLL & LABOUR COSTING

Three groups, comprising some 50 members representing a wide variety of potential, and a few actual, users of electronic equipment, studied the application of computers to payroll preparation and the production of labour costs and the problems involved therein. The following paper incorporates the reports of the three groups on a subject which is generally accepted as being one of the largest, most universal and most contentious fields of computer application.

FACTORS AFFECTING THE SCOPE OF THE STUDY

1 In the main only general consideration was given to the subject; the comments and conclusions arrived at are not firm and must be viewed in the light of the following factors -

(a) The very limited amount of practical computer experience available among members;

(b) The lack of a specific payroll and labour costing problem;

(c) The fact that payroll and labour costing was considered in isolation and not related to other work; and

(d) The inability to restrict consideration to any particular type of computer (e.g., large, medium-sized or small).

THE APPROACH TO THE PROBLEM

2 The study of the problems involved in this application of computers covered the following fields -

(a) Analysis of pay-roll procedure and computation - in relation to re-organisation of existing systems and planning of the machine program.

(b) 'Prime' and 'end' documents. To what extent will they need to be modified in a computer installation? How far might it be possible to effect a reduction of clerical handling of data? What is the nature and form of the final product required? What analyses are required for accounting and managerial purposes?

(c) Flow of data to and from the computer and problems arising from centralising calculation.

(d) The various methods by which some of the basic payroll computations can be tackled in a computer system (i.e., the handling of the time factor, computation of gross wages, methods of dealing with tax, various deductions, etc.).

(e) The relative merits of various forms of input and output.

(f) The organisation and staffing problems arising from or affecting a computer installation.

(g) The economics of the computer - manpower saving - clerical staff - machine staff.

(h) Does the computer offer the prospect of better service? If so, what improvements would be desirable?

(i) Does payroll and labour costing call for special features in a computer?

(j) Integration of payroll with other computer uses.

FACTORS AFFECTING DECISIONS TO PUT PAYROLL AND LABOUR COSTING ON TO A COMPUTER

3 While, because of the lack of a specific application, detailed consideration was not given to the factors which would affect a decision on whether or not to put payroll and labour costing on to a computer, it is evident that the decision would depend to a large extent on a combination of the following -

(a) The numbers of staff to be paid: are the numbers sufficiently high to warrant the installation of a machine with the capacity of a computer?

(b) Complexity of operation and variety of grades: are the processes involved (for example, the calculation of piece work payments, bonuses and deductions) of such a nature as to make a computer uneconomical?

(c) Time factors: bearing in mind the preparation of data involved in a computer process, and the fact that the payroll may have to be channelled through one machine, do circumstances allow sufficient time for these processes to be carried out?

(d) Improved service: is there a need for further information or for it to be obtained more quickly than is possible under the existing system? Can this improved service be given only by the installation of a computer?

(e) Organisation: does the organisation, in its internal structure and/or its geographical dispersal, permit the centralisation of payroll and labour costing?

(f) Alternatives: what alternatives to electronic computers are available to suit individual requirements, and how does the cost of these compare with the cost of a computer installation?

(g) Integration of payroll and labour costing with other work: is payroll and labour costing the only work to be put on to a computer or can it be integrated with full costing, budgetary control and so on? What is the extent of this and other work and is it sufficient to make a computer installation economical even although payroll and labour costing itself would not be so?

IMPROVEMENTS TO BE LOOKED FOR WITH A COMPUTER INSTALLATION

4 With a computer installation one or more of the following improvements could be expected -

(a) Simultaneous or early production of statistics and managerial information with payroll.
(b) Accurate payments at an earlier date than is now sometimes the case in respect of bonus and similar calculations, instead of payments 'on account' which have to be adjusted subsequently.
(c) More accurate work with the possibility of more automatic checks and less likelihood of fraud.
(d) Reduction of routine clerical processes.

EFFECT OF COMPUTER INSTALLATION ON ORGANISATION, STAFFING AND PROCEDURES

Organisation And Staffing

5 In the initial stages at least, the installation of a computer would do no more than ease the staffing recruitment problem. Redundancy sems unlikely and any staff savings would probably only keep pace with wastage. Eventually, no doubt, there would be a reduction of clerical labour, but this might be offset to some extent by an increase in punching staff. It is possible that clerical staff would need to be of a higher calibre than is now generally the case and that they would require a reasonable understanding of computer processes to enable them to deal intelligently with any circumstances which had not been foreseen and allowed for in the program. So far as organisation is concerned, it is considered that it is unlikely that regions would be catered for at the centre to any great extent until teleprinter or telex services (particularly error correction in transmission) are further developed.

Input And Output Documents

6 Punched cards would appear to be the only practical form of input for payroll purposes until magnetic tape is more generally available, except perhaps in relation to variations from standard. The potential high speeds possible with magnetic tape would probably outweigh any disadvantages.

7 In the circumstances now existing, and likely to prevail in the foreseeable future, it is probable that data for payroll and labour costing (as indeed for any other type of work) will generally have to be processed by punch operators before it can be fed into a computer. Mark sensing and mark scanning are possibilities and experiments are being undertaken in other methods (e.g., the creation of punch documents for input simultaneously with clocking on and off, etc.) but these are likely to have very limited application. In considering the most efficient scheme for the input of data to a computer, therefore, the important elements appear to be the extent of the labour required in the amplification, rearrangement, sifting, etc., of information on prime documents prior to punching, and the extent of punching itself.

8 The type and capacity of the computer in use would affect both of these, of course, but with any given computer the two main factors would be
(a) the 'system' of prime documents used, and
(b) the extent to which the computer could be programmed to meet requirements with the minimum of variable input data.

9 On (a) the ideal would be to have prime documents so designed and covering such specific purposes that the clerical work necessary prior to punching would be reduced to a minimum or even eliminated. This has always been an important consideration in any punched card operation but, with the considerably greater flexibility of a computer, it may prove possible to move much nearer to the ideal.

10 The extent to which punching can be reduced by programming depends largely upon the economic balance between the labour element and computer time. For example, with a simple payroll which did not vary greatly from week to week (say a payroll for clerical staff), instead of a 'positive' system of punching and feeding-in information each week for each man, the computer could be programmed to produce details of a standard gross pay for each employee (from a master tape or card) unless notified of a variation. Such an 'exception' system would not only reduce punching but it would probably be less expensive in computer time as there would be less input of cards. With a more complicated payroll, or one which varied appreciably from week to week, it could be that an 'exception' system would result either in more punching than a 'positive' system or in the computer program being so involved and taking so much time as to make the computer costs, compared with labour costs, disproportionately large.

11 Important considerations in deciding the system of documents to be used are the need, in certain circumstances, for hours of payment to be confirmed from a secondary source of information and the need for variable information being fed into a computer to be accurate. It may be possible, of course, for information from two different sources to be compared within the computer and, if they did not agree, for an indication to be put out on an 'errors' list. In all the circumstances, however, and bearing in mind the needs of audit and the amount of recording necessary with bonus and costing jobs of any complexity, it would appear unlikely that existing prime and end documents would be modified to any appreciable extent.

Personal Record Cards

12 While fully appreciating the problems that the maintenance of a personal record would throw up in a computer system, it is considered generally that a record card in some form would need to be kept. The ideal would be for all the information required as a personal record to be stored in the computer, or in a form suitable for the computer and readily available for inspection; but to have this information in this form with weekly totals (as is now generally the case with personal record cards) would probably prove too big a storage problem for a computer to handle. The need for a personal record card, the form it should take and the problems it would throw up are matters which should be the subject of separate detailed study. (A suggested form of personal record for a monthly payroll using a punched card computer is described in the Appendix).

Procedures

13 Important advantages (in relation to payroll) would probably arise from the need - inherent in the installation of a computer - to overhaul existing procedures and organisation.

14 The period between the end of the pay-week and the time of payment might require alteration in relation to centralisation. Additional time might be needed for transmission of data.

15 There are two broad methods of collecting data for the compilation of gross wages (i.e., clock cards in factories and time sheets in occupations where work reporting places are widely scattered). In the former, the ultimate aim should be the preparation of clock cards with such simultaneous ganging-in of information as to render the manual calculation of total weekly hours, overtime, etc., unnecessary. In the latter, it is difficult to see how a certain amount of calculation can be avoided.

16 Allocation to cost heads should ideally be undertaken before the process of machining so that costs may be computed as a by-product of the payroll. There might be little point in complicating the machine process if payroll staff were unemployed in the latter part of the week and, in these circumstances, allocation might well remain as a subsequent clerical function. Decisions on a point of this nature have clearly to be taken having regard to the overall staffing position of the particular organisation.

Programme of work for computer

17 Maximum benefits of a computer installation could only be achieved by the integration of payroll and labour costing with other work. Not only is one sort of information then used for several processes, but also payroll and labour costing on its own would give rise, because of the time factor, to a 'peak' of work at one stage during the week which would probably lead to an unbalanced utilisation of staff time. Experience may show that, in a large concern with, say, several watertight departments, faced with alternatives of putting payroll and labour costing for all departments on to a computer, or putting payroll and costing and other integrated work within one department on to a computer, the latter would provide the more economical use of the equipment.

EQUIPMENT REQUIRED

18 Payroll calculations in a computer system fall into two broad categories - those in a fully automatic system and those where a certain amount of manual calculation is accepted. Generally speaking, payroll in the first category involves one of the larger makes of computers, whereas those in the second category should be based on one of the smaller machines.

19 Obviously, the equipment (both the computer and the peripheral equipment) must be reliable. Other requirements are

(a) multi-channel input and output to cope with the simultaneous feeding-in and output associated with a payroll and labour costing job,
(b) as large an internal storage as is economically possible to handle not only an extensive program, but also to provide a reasonable store in which to hold data in suspense during the processing of payroll and labour costing,
(c) ability to amend stored information easily,
(d) ability to extract any particular information required easily,
(e) a flexible computer system capable of being varied to meet individual requirements,
(f) a fast operating (as distinct from calculating) speed,
(g) simplicity in programming and operating, and
(h) a printing mechanism compatible with the speed of operation of the computer.

20 The incorporation of checks in the programme is regarded as important. It is not considered sufficient to rely on test runs. This factor might influence the choice of a computer.

SAFEGUARDS

21 Despite increasing standards of reliability, preventive maintenance, etc., standby arrangements (particularly in respect of payroll as distinct from costing) would have to be made to guard against breakdowns. Possibilities would be a standard wage payable

in emergency; an agreement with the manufacturer or neighbouring concern using similar equipment to use their machine in the event of breakdown: working outside normal hours (this last suggestion is not as easy to arrange with female staff as it is with male staff).

APPENDIX

HISTORICAL RECORD FOR A MONTHLY PAYROLL USING A PUNCHED-CARD COMPUTER

1 The payroll for which this method has been suggested covers some 15,000 monthly-paid Civil Servants. One of the main features of such a payroll is that most of the payees are paid in accordance with basic scales which include increments of which the date and amount are known well beforehand; another feature is that in present circumstances overtime is so rarely payable that its mechanical computaton would probably be uneconomic.

2 The elements of pay appear on a series of punched cards for each employee. These are as follows -

(a) The 'Status Card', carrying basic information (about grade, incremental date, whether or not on London rates, etc.) from which changes of rate of pay are calculated; this card is not normally required for each payrolling operation.

(b) The 'Standing Card', bearing the monthly rate of pay calculated from the Status Card, and other information which, although it rarely alters, is needed for each payrolling operation (e.g., tax code, type of insurance stamp, regular contributions to National Savings, etc.).

(c) The 'Cumulative Card', which is replaced mechanically each pay day and carries, besides Gross Pay to date and Tax to date, certain 'once-only' information (such as a variation from the standard number of insurance stamps to be deducted for the month).

(d) A number (usually zero) of 'Variations Cards' carrying various more-or-less rare additions and deductions, some taxable and some not, such as rent for Crown-owned houses, lodging allowances, overtime, recoveries of advances, et alia. These cards are so coded as to facilitate analysis for posting to the hundred or more different ledger accounts which may be affected.

3 To a large extent, therefore, the historical record is contained in the cards themselves. The fairly large-scale operations such as back-dated applications of pay awards, some of which may depend on the last two years' history for each man, can be programmed and performed without reference to any visual record. However, the contents of each card are mechanically printed near the edge of the card so that visual reference is possible when the histories of a few men only must be studied.

4 The main purpose of an historical record, apart from those served by the above methods, is to provide rapid answers to those queries which (in spite of carefully designed pay advice slips) always reach the Pay Office shortly after each issue of pay. Experience has shown that such queries arise from the presence of unexpected changes in pay, or from the absence of expected changes, and rarely from other causes. The answers may best be found, therefore, from a record of changes uncluttered with standing information.

5 An 'Alterations Record' has therefore been suggested, which would serve the two purposes of (a) providing answers to such queries and (b) presenting the changes to the machine room; the latter is perhaps the more important. The suggested record would be in the form of a card, some 12ins. x 15ins., bearing columns representing those fields of the punched cards which may be directly amended on clerical instigation. It does not represent fields whose contents are altered by mechanical computation of the effects of other amendments; for instance, the tax code is represented by a column, but one month's tax-free income (which is mechanically computed from the tax code) is not.

6 The Alterations Record would be laid out in such a way that the changes recorded upon it are clearly identifiable both as to date and as to the pay element changed. It would also be in a form from which operators could conveniently punch amendment cards for presentation to the computer. Entries would be made on it only when changes occurred; usually, the new absolute value of the changed data would be recorded, but some temporary changes would be indicated by the size and direction of the variation from normal. Such a record might well be of great value for a payroll of this particular type; its usefulness in connection with other types of payroll has not been studied.

6 - SALES ACCOUNTING, CONTROL AND STATISTICS

REPORT 6A

SUBJECT DEFINITION

1 The study of Sales Accounting for this purpose excludes Stock Control. The study commenced, therefore, from the time of the delivery of the goods, and the stage of preparation of the order/invoice with its attendant credit control, through the process of keeping records of customers' accounts and includes collection of payment from the debtors. Statistics will be produced, as required, from the processing of the data resulting from the Sales Accounting functions.

METHOD OF APPROACH

2 Consideration was given to the following points during study of the subject -

(a) methods of preparing information for presentation as input media,
(b) processing facilities and storage capacity of a computing system together with output requirements as file records or for printing of data,
(c) actual case-studies of manufacturing and sales organisations, with particular reference to integration problems,
(d) the possible advantages or otherwise in the use of some punched card facilities in the field of statistics as well as Sales Accounting, and
(e) the economics of the system relative to the size of the organisation considering computer applications.

GENERAL COMMENTS AND CONCLUSIONS REACHED

3 A copy of an actual case-study embarked upon during the Session is given as an appendix and various comments upon the methods suggested therein are included.

4 Although it is appreciated that the requirements of different companies are likely to vary considerably, it is felt that the basis of this case-study will, perhaps, be common to many, and will serve as a suitable guide in approaching their own problems.

5 Further case-studies would be desirable to cover different requirements before general conclusions could be put forward.

6 However, it is realised that until practical experience has been gained any conclusions reached are tentative.

Appendix

CASE STUDY ON AN IMAGINARY COMPANY

1 This is a company engaged in the manufacture of products for sale from stock. A few orders for special manufacture are accepted but are treated as exceptions to normal.

2 Goods are manufactured and stored in bulk, some 6 000 products being available in a central warehouse.

3 Goods are distributed through 12 branches which hold stock of some 4 000 products and order specially from the central warehouse any lines not held. These may be sent direct to a customer in cases of urgency but usually go through the Branch.

4 A back order situation can occur and must be allowed for; so also must the fact that orders are not dealt with in strict rotation due to the sub-division within the distributing warehouses according to type of product and the sub-division of orders according to van delivery schedules.

5 Statistical information is as follows -

Branch	A	B	C	D	E
No. of Customers	982	4 373	2 947	1 510	3 609

F	G	H	I	J
2 500	2 000	13 129	3 657	1 246

K	L	Total
2 000	1 608	Customers - 38 41

Maximum Orders/Invoices - 4 000 daily
Number of Lines per Invoice - 1 to 50
Average 4
Ledgers - 40, loose card type posted daily by accounting machines through statement
Postings to Accounts - 1 to 50 during month
Average possibly 2
Cash Receipts - 100 to 2 000 daily; cash discount allowed on the current amount
Sales Analysis - Weekly report of sales for year to date under 37 product headings, compared with similar period of previous year
- 4 weekly report of sales for year to date compared with similar period of previous year, under

12 branches by 10 trade classifications
10 trade classifications by 74 product headings
- listing of customers with sales, under 37 products (assumed no one customer has more than 16 products)
Clerical Staff Employed - approximately 150

ORDER PREPARATION AND INVOICING

6 The Study Group considered two methods -
(a) Typewriter with paper tape output, and
(b) Pre-punched cards.

Typewriter With Paper Tape Output

7 Customers' orders on receipt are sorted into order by name or code number, to facilitate processing in computer against sales ledger data.
(Note - Orders received later in the day would have to be actioned in random sequence; routing for van deliveries would require sorting into areas)

8 Warehouse documents are prepared on typewriters, using prepunched master record cards for -
names and addresses,
commodity description, price, purchase tax, etc.
Variable data (order no., date, quantities, etc.) are entered manually from the keyboard.
(Note - The operator may pull and re-file the master cards for each order herself, or it may be necessary for this to be carried out by another clerk to gain maximum output)

9 Simultaneously punched paper tape is an output from each typewriter, pre-set to punch only the details required for processing by the computer, such as -
customer code no.
customer order no. and/or date,
full commodity details (price, p. tax, quantity).

10 Amendments (items out of stock, or part deliveries, etc.) to main tapes would be necessary when warehouse had dealt with orders.
(Note - Two suggestions: amend tapes at Branch, or program computer to handle them during input feed. The former appears preferable)

11 Completed tapes are posted daily from Branches to Data Processing Centre at Head Office.

12 Branch tapes are processed daily through computer to give invoice details on magnetic tape, which is then fed to high-speed printer for production of invoice documents.
(Note - Two methods are possible -
(a) Feed in all data, calculate extensions, p. tax, and invoice totals in the computer and then print out;
(b) Feed in selected data only, and call in such as names and addresses, commodity descriptions, prices, etc. from magnetic tape storage, then calculate and print out as in (a).
(b) may well be faster than (a))

13 Invoice values and commodity details are stored for subsequent processing with Sales Ledger and Analysis procedures.

Pre-punched Cards

14 Produce warehouse documents by 'single-print' system as at present.

15 Copies of warehouse documents are sent to Head Office daily after goods have been despatched.

16 Master pre-punched cards are pulled for each warehouse document as regards -
names and addresses, and
commodity details and prices.
(Note - Data preparation time is not very fast; certain extra detail (e.g. customer code no., quantity, etc.) have to be inserted in the cards; relatively slow means of input)

17 Cards are fed into computer, values calculated, totalled, and details produced in the form of magnetic tape (or on punched cards) from which to print invoices.

18 A by-product would be assembling data either within computer or as punched-card output for Sales Ledger and analysis work.
(Note - Punched cards can be sorted away from the computer - saves computer time)

SALES LEDGERS

19 Following upon the comments regarding the use of punched cards in the preceding paragraphs, it is clear that it is feasible for the Sales Ledgers to be maintained on punched cards. However, in view of the volume of data involved it is considered more expedient to use magnetic tapes.

20 The basic principle uses an invoice no. which comprises the customer's code no. and the sequential number of invoices issued to him (e.g., 12345/1, 12345/2, etc., with the suffix starting from 1 each year).
(Note - Usual form of numerical sequence control would require revision)

21 Ledgers would be maintained on magnetic tapes, say two Branches per reel of tape. Accounts would be maintained on 'open item' basis in number sequence

quoted in paragraph 20, showing goods and p. tax together with factor of allowable settlement discount period.

(Note - Data for ledger 'posting' would be from invoice amounts and customer code nos. stored on magnetic drum as invoices were being calculated)

22 Statements prepared from the magnetic tapes at each month end and sent to the customers; labelled with customer no. and date for reference upon reurn. One office copy retained.

23 Cash and remittances input would be by paper tape, giving -

customer no. and date of statement (unpaid items being re-debited),

invoice no., and total cash and discount deducted.

(Note - Part payments to be credited, but account printed out for interrogation)

24 Output from that operation would be by electric typewriter, control listing all items extracted from the ledgers, agreeing with cash banked.

(Note - Traders credits notified by bank to be included)

SALES ANALYSIS AND STATISTICS

25 Opinions differ as to whether or not punched cards might be more suitable because of the advantage of sorting away from the computer. However, individual circumstances of each company's requirements will decide between a computer and punched cards, or a mixture of both.

26 On the present case-study the Weekly Sales report (year to date) under 37 product headings, compared with the similar period of the previous year, would be a simple matter on a computer.

27 During the invoice run, the computer would analyse and store products cumulatively under 37 headings, with output on to magnetic tape from which to up-date a weekly sales report cumulative (year to date) tape during another run on computer. The latter tape would also contain previous year's data from which to print comparisons required.

28 If invoice run uses punched card input, cards could be sorted afterwards as required. Summary cards of previous sales (year to date) would be added manually before printing new totals. Cards for previous year's data would also require to be manually inserted in the printing run.

(Note - Computer operations in paragraph 27 are preferred to the operations in paragraph 28)

29 The 4-weekly period sales report (year to date) for each branch by 10 trade classifications (by 74 product headings) could be a good subject for standard punched card techniques, but not when comparison with previous year's date is also to be included.

30 As computer invoicing run was carried out branch by branch, the 10 trade classifications could be picked out at the same time provided that product code nos. included both trade and product group identification. The 10 trade classifications by 74 product headings would probably require to be printed out from second run of invoice tape.

(Note - A comprehensive product code appears to be required, with the production of a detailed statistics tape after the invoice run so that the analytical work and updating of records can be done as another computer run)

31 The analysis of customer turnover under 37 products could be produced as an extension of the Sales Ledger tape, or by standard punched card techniques.

REPORT 6B

DEFINITION OF SUBJECT

1 The study of the subject was confined to EDP relating to the movement of goods from a company's warehouse to its customers, the charging of customers, the receipt of cash from customers and the production of statistics relating to sales.

METHOD OF APPROACH

2 It was decided to relate these problems to a procedure designed to meet the needs of an imaginary company in the light of current knowledge of known computers. It was appreciated that the problems of this mythical company would not necessarily be generally applicable in all circumstances, but it was considered that the study would be of more value if related to a set of basic facts.

CASE STUDY

3 The case study based on the operations of the mythical company is given as an appendix. This represents a summary of the method of operation which the majority of the group favoured as each phase of the operation was discussed. Certain points on which alternative suggestions are put forward, or which remain unresolved, are dealt with in the following paragraphs.

Method of Ledger operation

4 The main point of detail on which there are varying views is the best method of keeping customers' accounts. Certain companies will find that a combination of the Open Item and Balance Forward systems will suit their purposes better than having the whole ledger on one system. The need for customer histories is another matter on which opinions differ; this, as with the statement procedure, is bound up with the method of ledger operation.

Customer Numbering

5 The numbering of customers in large organizations which have a number of territory changes (not necessarily annual) must be settled before the introduction of EDP. Any one company could settle on a system based (say) on county, town, and customer number within town. This has the merit of being static (i.e. independent of changes in salesman and territory numbers) but there are still further advantages to be gained if this number can be part of a national scheme. In the case of remittances received, for example, all manual coding processes could probably be eliminated whether the customer returns a document or not.

6 It is understood that the Clearing Banks have set up a committee to study the numbering of customers from their viewpoint; it would be of great advantage if the banks were to allocate a national number to every business and individual in such a form that information shown on cheques, etc., could be used by commercial concerns in their own sales ledger and other systems. It would be important to avoid any possibility of duplication in the system of allocation and to restrict the number of digits in use to the minimum consistent with positive identification.

Checking Systems

7 There is marked divergence of opinion on the extent of the check required between the input and the output of the computer. Some consider that a gibberish total of all input should be maintained (imposed externally) and that a rigid control of output using the same figures would be necessary. Others contend that a commercial risk should be taken on such detail and that so long as the correct number of (say) invoices is prepared this is sufficient safeguard. This matter can probably only be resolved after the computer has been in use commercially for a period.

Appendix

CASE STUDY ON AN IMAGINARY COMPANY

1 Statistical information is as follows -

(a) 140 000 accounts;
(b) 250 travellers (i.e., average 560 accounts per traveller);
(c) average 3 000 invoices per day;
(d) 3 main depots.

2 The object is to prepare the following in the minimum number of computer runs -

(a) Invoices and despatch documents complete with name and address from input of the following order details -
  (i) stock availability;
  (ii) credit limit;
  (iii) despatch point determined by total weight and/or destination;
(b) Stock records for three depots;
(c) Sales ledger and statements where necessary;
(d) Sales analysis.

A COMPUTER SPECIFICATION

3 The computer specification is based, as far as possible, on known and existing computers. Investigation would show whether all these features can be incorporated in one computer. It is possible that equipment with a different specification, particularly in regard to storage, will handle this proposition with similar efficiency.

4 The specification for the computer, at a cost not to exceed £100 000, is as follows -

(a) Electronic system including arithmetic unit and quick access store;
(b) Medium access store with a capacity of approximately 16 000 words;
(c) Two magnetic tape/film units;
(d) Necessary tapes or films - eight for name and address, which includes delivery instructions, credit limit and any other static information, plus one for ledger information;
(e) One punched card input and one paper tape input;
(f) One paper tape output unit;
(g) One magnetic tape output unit;
(h) Two high speed tabulators or four electric typewriters fitted with paper tape/magnetic tape converters, independent of the computer;
(i) Six card punches;
(j) Six punched card verifiers;
(k) Two high speed card sorters.

INVOICING

Input Preparation

5 Orders are received -

(a) direct from travellers by means of a pre-printed order card,

(b) direct from customers on their own order form by post, or

(c) direct from customers by telephone.

6 For (a), cards can be punched and verified direct from Travellers Order Card.

7 For (b) and (c), the order office will make out an order form in similar format to the Travellers Order Card.

8 The punched card will carry the following information -

(a) customer account no.	- 6 columns	
(b) traveller no.	- 3 columns	
(c) customer order no.	- 6 columns	
(d) date	- 6 columns	
(e) commodity code	- 3 columns	7 cols.
(f) quantity	- 4 columns	

9 (e) and (f) would be repeated for each line on the order. On an 80 column card there is therefore capacity for an order of up to seven lines with three columns for class of card, etc. Where an order exceeds seven lines a further card would be punched (including (a) to (d), gang punched without further key depressions by the operator).

10 Consideration should also be given to the possibility of using mark scanning or sensing techniques, preferably completed by the salesman at the time of taking the order. It is important that the volume of work thrown on to salesmen would not involve them in marking one card for each item, but that the average order should be capable of being compressed into one card.

11 These cards will then be verified by another operator or by standard mark sensing techniques and are then ready for sorting.

(NOTE: Alternatively the pulling of prepunched cards could be retained, but it was felt that there would be a loss of speed in processing by this method)

12 Sorting would be carried out over the (a) and (b) fields (i.e. account no. within traveller).

13 In addition to the program, the following information is stored in the computer -

(a) Names and addresses, etc. (stored on tape film - it is estimated that eight records will be sufficient to hold all relevant information for 140 000 accounts, including credit limits - store A)

(b) Ledger details (stored on tape/film - store B)

(c) Product description, price and unit weight (the 100 items and 8 discount groups can be stored in the quick access storage);

(d) Stock at the three depots (stored on the drum).

14 This information is fed in on an up to date tape at the beginning of each invoice run. This tape also contains the last invoice number; the computer will number subsequent invoices consecutively.

Computer Operation

15 The main steps in the computer process are as follows -

(a) Feed in the cards (paragraph 12)

(b) Select from store A the relevant name and address, special instructions and credit limit. By reading the account number from the card and selecting the address on the film for that account number, pass name, address and special instructions to output and retain credit limit in store A.

(c) Select from the drum the product description, unit price and weight, reading the commodity code punched in the card and selecting the appropriate position on the drum.

(d) Compute quantity x unit price, quantity x weight, and purchase tax, storing each extension until all lines for that one order are completed; the totals are then calculated, including purchase tax and discount where applicable.

(e) Check with stock position details for each line stored on drum. If one line is out of stock the details will be punched on tape output 2; if in stock will follow normal flow to be placed on tape output 1.

(f) Select from store B the outstanding balance; add total of invoice and check new balance against credit limit (in store A). If credit limit is greater, pass to tape output 1; if credit limit is less than new balance by more than a stated percentage, pass to tape output 2. Up date store B with the invoice total and invoice number in accordance with ledger procedure used.

(g) Check total weight. If over one ton, then goods should be despatched from a specified depot and stock figures amended on drum accordingly; if under one ton, despatch from 1, 2 or 3 depot, according to destination of goods, and amend stock details accordingly.

(h) Tape output 1 is in sequence in which invoices are to be printed by electric typewriters.

(i) Tape output 2 will consist of -

(i) lines ordered which are out of stock, and

(ii) orders which have exceeded credit limit.

As both (i) and (ii) will have full details of name and address, etc., a composite form can be used to act as an invoice in the case of (ii) where after checking it is decided to let the goods go, or in the case of (i) as an acknowledgement of order - 'goods out of stock will be delivered as soon as available.'

16 It would be possible to accumulate and store all information referring to out of stock lines for each depot and at the end of the run this could be punched on to tape and used to prepare a daily 'out of stock' position sheet. Details of stock would be printed every day for each item for each depot but a special run of out of stock items showing the demand for that day would be useful. When depots advise receipt of new stock, cards would be punched and the computer programmed to add new figures to those existing on the drum to bring stock position up to date.

17 Although the above description is given step by step, it will be appreciated that many of the functions would be carried out simultaneously.

SALES LEDGER

Cash Card

18 Cash is received either via a traveller or direct from customer. Cards will be punched and verified from remittance copies of invoices or statements, whichever are available.

19 This punched card will carry the following information -

(a) Customer account no.	- 6 columns
(b) traveller no.	- 3 columns
(c) date	- 6 columns
(d) invoice no.*	- 6 columns
(e) amount	- 6 columns

(*NOTE: If the Open Item system is used (see below), invoice numbers are essential; if they are not available on the remittance document the office copy must be looked out and the number copied from it)

20 Sorting would be carried out over (a) and (b) fields (i.e., account no. within traveller).

21 Ledger details for 140 000 accounts will be stored in the computer on tape film. One record will be more than enough to handle the volume anticipated. It will be up dated in the course of the invoicing procedure.

Alternative I - Open Item System

22 The computer process is as follows -
(a) Feed in the cards;
(b) Select from tape/film the ledger details to date of the relevant customer no. and compare cash card with ledger details.

23 In the majority of cases the only amount outstanding will be that of the last invoice and the cash payment will clear the account.

24 Where the cash paid agrees with the balance outstanding a nil balance will be produced and there will be no output to the updated Sales Ledger tape/film.

25 Where the cash paid does not agree with the balance (although it might appertain to one invoice), details of this account with the fresh balance should be punched out for reference purposes, in addition to storing the whole of the amended ledger information on the tape/film.

Statements

26 Statements should be produced on the cycle principle.

27 No information is required to be fed to the computer other than an instruction as to the range of account numbers for which statements are to be produced at that time.

28 The computer will need to hold -
(a) ledger details (held in tape/film store B), and
(b) names and addresses (held in tape/film store A).

29 The computer will search through the specified range of accounts. Where there is any amount outstanding the relevant name and address will be extracted and all information required to print the statement passed to output.

30 In certain circumstances the use of the Open Item system entails the production of particularly lengthy statements (e.g. when the customer regularly pays cash on account). To overcome this it may be desirable to instruct the computer to calculate and punch out those transactions that have occurred since the previous statement and to punch out a 'Balance Brought Forward' from earlier transactions. This would mean that for queries reference might have to be made to more than one copy statement to cover the necessary period.

31 It is probable that only practical experience will show the most effective way of dealing with the problem.

Alternative II - Updated Statement System

32 In any one day the ledger film (tape/film store B) will only contain outstanding balances and details of that day's movements.

33 At the end of the day the computer is programmed to give an output of -

(a) details of the day's transactions and new outstanding balances for accounts which have changed, and

(b) outstanding balances for those accounts which are due for statements (daily cycle) but which have had no movement for the past month, and the respective names and addresses.

Ledger Cards and Statements

34 The equipment used would be a spirit 'line selection' duplicator. Output from the computer would be printed on continuous hectographic master paper (in account number order). Using the line selecting machine the ledger card and statement can then be produced.

35 This means that the day after the books are closed the statements are up to date and ready for despatch.

36 Output information from paragraph 33(b) above will be used in preparation of statements for those accounts that have not moved during the current cycle.

37 As a refinement the computer could be programmed to give additional information if the transaction is the first of the current period. This is used to post the opening balance on the new statement with the name and address.

SALES ANALYSIS

38 The computer would be programmed to produce a variety of sales analyses.

39 A statistical tape would be prepared during or after the invoice run and from this would be prepared an analysis showing -

(a) territory no.,
(b) district no. (group of territories),
(c) value of sales by group of products, and
(d) sales quota by group of products.

40 Daily tapes would be combined to produce weekly reports and these in turn would be combined to produce district and divisional reports.

41 Subsidiary information from the daily statistical tape would be the total quantities despatched by despatch point by product and pack.

7 - STORES CONTROL AND MATERIAL COSTS

DEFINITION OF SUBJECT

1 Preliminary consideration suggested that stores control covered such a wide and important field that adequate attention could not also be given, in the time available, to material costs. Detailed investigation of the latter was therefore not pursued.

2 Stores control was defined as:

'the formulation of a system of stock control, distribution, and accounting, suitable for computer application, having the following objectives:
(a) to ensure that adequate stocks of items are available at the right times and in the right places,
(b) to account for all items delivered to stock,
(c) to ensure that the minimum amount of the Organization's resources are absorbed by stock-holding activities'.

METHOD OF APPROACH

3 The case study method was employed, based on a report of a fact finding investigation of an actual commerical stock control and distribution procedure. The main contents of this report are set out in Appendix A.

4 A report on the main features of the case study is given in Appendix B. In the time available it has not been possible to complete the more thorough investigation which would be necessary in practice.

5 In carrying out this study, it was found helpful to proceed in the following sequence -

(a) It was considered essential, for clear appreciation of precisely what the system was to be designed to achieve, to define, from first principles, the objectives of the organization. It was thought that, in this way, there would be less danger of including as 'requirements' for the computer system items of work which, though carried out under present arrangements, were not essential to achievement of the overall objectives.
(b) The requirements which it was considered the computer system must fulfil to achieve the objectives of the organization were then enumerated, and the general arrangements of the computer

system were formulated, including a broad outline of the proposed flow of data to and from the system.

(c) The following elements of a centralised computer system were specified in some detail -

(i) input;
(ii) computer records;
(iii) output;
(iv) calculations required to be performed by the computer to obtain (iii) from (i) and (ii).

(d) The first of these items to be studied was output. It may seem unusual to determine the 'last link in the chain' first but this approach is the logical extension of the principle of firstly determining the main objectives and then designing the system to satisfy these objectives.

(e) The study aimed to specify the minimum amount of printed output to give management adequate information on which to base judgement when circumstances required this action; the 'exception principle' was therefore applied whereever possible.

(f) In considering what data should be maintained in the computer - or in records associated with it- the maximum benefit will be obtained from the system if the variable input, which has to be provided by clerical effort, is reduced to the minimum by including in the computer records as much as practicable of the essential data.

(g) In determining the calculations required of the computer, it is probable that more sophisticated use of the machine's abilities might be made in connection with forecasting requirements of goods, but it was considered that this was a matter which could more appropriately be dealt with by staff having adequate time for study of the matter and a detailed knowledge of forecasting techniques.

(h) To complete a full report on potential application it would be necessary to provide statistics of the volumes of the various types of data and digit counts to be handled by the machine. Whilst most of the statistics are available from the original fact finding report it has not been possible in the time available to prepare the necessary detailed statements.

GENERAL COMMENTS AND CONCLUSIONS REACHED

Suitability for Computer Application of Case Studied

6 It was agreed that the routine office work involved in the case studied could be undertaken by a suitable computer and that, additionally, the system would provide

(a) better control of the stores organization, and
(b) more useful information for management.

7 Whether the application of a computer system would be economical in this particular case depends largely on

(a) the cost of the equipment required, and
(b) the extent to which other associated work might also be undertaken by the computer.

8 As regards 7(a), computer manufacturers would have to be asked to quote for the supply of the equipment they recommended for the job. In this connection, two manufacturers offered to examine the case study report and to give their tentative views on the practicability of the computer work specified. Their comments are set out in Appendix C.

9 As regards 7(b), the data required by the computer system for stores work could also be used for other purposes (e.g. sales accounting). Whilst it was impracticable in the present study to investigate such associated activities it would clearly be advantageous to do so before going to computer manufacturers.

Suitability for Computer Application of Stores Work in General

10 Based on this case study, it is concluded that the work of stores control, distribution and accounting can be done effectively by computer. The practicability of applying a computer economically in a particular case depends on comparison of the cost of doing the work by a computer with that of doing it by conventional methods, taking into account improved accuracy and efficiency.

11 Investigation of potential computer applications necessitates careful O. & M. work to establish facts and to assist in determining requirements.

Appendix A

CASE STUDY ON STORES CONTROL AND DISTRIBUTION

INTRODUCTION

1 The Company concerned is a manufacturer of photographic goods and materials on a large scale, which can be broadly classified under six main headings -

(a) Photographic Papers
(b) Photographic Films
(c) Photographic Plates
(d) Cameras
(e) Sundry Photographic Apparatus
(f) Chemicals

2 This Appendix gives a broad outline of the present system of distribution to the home market.

3 The finished products of the company are received from the various factories by the Distribution Centre, which is responsible for the company's centralised warehouse and despatch activities. Supplies of finished goods are requisitioned on the Distribution Centre by the Company's ten Wholesale Branches.

SUPPLIES TO HOME MARKET

Wholesale Branch Stock Control System

4 For convenience in the compilation of statistics, the Company uses periods of four weeks (with thirteen periods constituting a year) in place of calendar months.

5 It is usual for branches to hold between two and three periods' stock of each item. However, where sales of an item are small, and 'shelf life' permits, larger stocks may be carried to allow economical quantities to be ordered at any one time. In addition, where a particular item is a consistent seller in large quantities, production may be geared to meet these stable needs so that the stocking basis in branches will be reduced to as little as one period.

Stock Counting

6 At present each branch controls its own stock levels. Once each period all stock in branches is counted. The stock count and receipts during the period are recorded on stock record sheets. From the figures for period opening stock, receipts and closing stock, the consumption (sales) for each period is calculated.

Stock Replenishment

7 Stock orders are calculated as follows -

(a) a moving annual total (i.e., sales for the latest thirteen periods) is used to determine average sales per period, including current sales trend;
(b) this figure may be modified by the stock-keeper's judgment if he thinks this necessary;
(c) this modified period sales figure is then multiplied by the period stocking basis shown on each stock record sheet;
(d) The result of (c) is then compared with the latest stock count figure. If the stock count figure is smaller the difference is rounded off to the nearest quantity of items contained in intact bulk cases. This quantity is ordered on the Distribution Centre by a branch order.

8 The branch order is a single item form in four copies -

(a) delivery note - returned to the branch with the goods;
(b) order copy - used for accounting purposes;
(c) planning copy - used for calculating production orders on the Factory to meet future needs;
(d) branch copy - retained by the branch stock-keeper for order progressing.

9 Each order is allocated a date/order control number at the time of origination, consisting of the day and month of origination and a sequential number (recommencing daily at zero) (e.g. 15-4-92, 15-4-93, and so on). The last order originated each day bears the suffix 'X' for identification by Planning Department, to ensure that all orders from branches are received (see paragraph 19).

10 The top three copies of each order are sent to the Distribution Centre (Stock Planning Department), the fourth copy being retained in the branch.

11 At the end of each period, each Wholesale Branch renders a statement to the Sales Estimating Department of stock counts and calculated sales.

Distribution of Goods to Wholesale Branches

12 The complete stock held in a Wholesale Branch is not counted or ordered at one time, but stock counting and ordering functions are carried out progressively during a four-week cycle. This spreads the work of stock counting, ordering and handling deliveries of stock orders.

13 As far as possible deliveries to branches by the company's own transport are made on certain days in the week. Where contractor's transport is employed, it is not possible to schedule deliveries for arrival on any precise day.

14 On receipt by a branch, goods are checked against the delivery note; the goods are then taken into stock and the stock record books entered.

Statistical Data

15 24 staff are employed in Wholesale Branches solely for the purposes of ordering stock and maintaining stock records. The labour required to originate branch orders is not included; this is primarily a typing operation but often forms only part of an individual's job.

16 The number of stock orders placed totals about 150 000 a year.

17 The range of items stocked by any branch will probably differ from the ranges of items stocked by other branches; the total number of items at any one branch varies from 1 800 to 4 400. The Distribution Centre stocks about 5 800 items.

DISTRIBUTION CENTRE

Stock Planning Department

18 This department maintains a perpetual inventory of stocks held in the Distribution Centre. Receipts are obtained from delivery notes accompanying goods received from factories and consumption is obtained from unit branch orders. The present form of perpetual inventory record comprises -

(a) type dissection record (voltage, pad colour or serial number control),
(b) outstanding order sheet (i.e. stock not available),
(c) sales dissection record for export orders,
(d) sales dissection record for home orders,
(e) perpetual inventory record, and
(f) moving annual total record of consumption.

(Note: In each stock record set only forms (c) to (f) will always be present; form (a) will be produced only when an item is manufactured in several variations (i.e. voltages); form (b) will only be present when the stock is not adequate to fulfil orders received.

19 After each order has been controlled numerically the type dissection card (if any) is referred to and checked to ensure that stock is available. If no stock is available, the order details are entered on the outstanding order record card. If the item is in stock, the amount available is reduced by the quantity of the order received and the order passed for execution. At the end of each week, consumption previously recorded on typed dissection cards is totalled and transferred to the main perpetual inventory record card. Consumption is also entered on the export and home sales dissection cards each week. The moving annual total card is used to determine what level of stock of the particular item should be held in the Distribution Centre to meet forthcoming commitments.

20 After the order has been entered on the stock record, the top two copies are released to the Warehouse for execution and return of the order/invoice copy to Stock Planning Department; this copy is paired with the planning copy for control purposes. The planning copy of the order is filed and the invoice copy passed to the Invoicing Department for stock accounting purposes.

21 The four-week ordering cycle spreads the work of handling orders in Stock Planning Department.

Staff of Stock Planning Department

22 The Stock Planning Department consists of a number of sections, each responsible for maintaining the perpetual inventory for a specific group of products -

(a) paper stock control,
(b) film and plate stock control,
(c) chemical stock control, and
(d) sundry apparatus and camera stock control.

23 There is a further section whose main task is progress chasing of orders received in the department.

24 Each of the stock control sections consists of stock record clerks who maintain the perpetual inventory, and planning clerks who calculate production orders for placement on factories. Excluding the production planning clerks (it is thought unwise at this stage to include these functions in a computer study) and departmental management, the staff of the department is -

Supervision	5
Order progress controllers	2
Stock record and progress clerks	18
Stock record controllers	4
Stock record clerks (juniors)	5
Filing clerk	1
Stenographers	6
Total	41

Sales Estimating Department

25 The major function of this department is the presentation to management of up-to-date information of the company's progress compared with estimate. This is normally done once each period but it is also necessary to keep management advised at shorter intervals where, for example, products become short in stock during the peak summer season.

26 Ideally this would mean that there should be a continuing picture of the latest information on stock, sales and production dissected into major product groups.

27 Three factors affect the position of the business as far as stock is concerned -

(a) stock in hand
(b) production, and
(c) sales

28 There are minor adjustments, such as returns by customers, but these can be regarded as negative sales, whilst condemnations of stock and withdrawals from stock for testing purposes can be regarded as negative production.

29 Provided any two of the above three items are known, the third can always be calculated. As production is known the decision has to be taken whether to count stock at intervals and assess sales since the last stock count, or to accumulate sales data and so calculate stock. This is complicated however when

stock is located at more than one point and when it is required to know the individual stock at each location.

30 As far as the overall company picture is concerned, the location of stock is not important as this only concerns distribution problems. However, it is necessary to control the levels of stock located at individual Wholesale Branches so as to keep overall stock at a minimum level consistent with good service to customers. At the moment the company employ both methods of compiling stock information. In the Distribution Centre, a perpetual inventory is kept on which a balance is struck weekly. The Sales Estimating Department extract information on branch stocks and sales by the branches counting their stocks and calculating their sales once every four weeks, and passing these figures to Sales Estimating Department.

31 There are considerable disadvantages in the present system -

(a) There is a peak of clerical work at the start of each period, both at the Wholesale Branches and in Sales Estimating Department, resulting in the elapse of four to five working days from the day of the branch stock count to the day when Sales Estimating Department receive branch stocks and sales figures. This does not include the time taken to compile figures for Distribution Centre stocks.

(b) Due to the clerical work required it is not possible at present for Sales Estimating Department to compile statistics of as many items produced by the company as they would like, particularly statistics of paper and chemical products, which consist of a large number of lines. The work involved in making out branch reports on all these items and in casting and sorting these reports would constitute an enormous task and one which the company do not consider it is feasible to carry out by present methods.

(c) At present the Sales Estimating Department are not informed of receipts of goods by branches or of movements of stock from one branch to another. As a result goods in transit from one location to another have to be assessed by various means which are not always accurate.

(d) Stock counts at Wholesale Branches do not coincide with the dates of stock balancing in the Distribution Centre. Branches make counts of certain groups of items on each working day of each period to spread the work of stock ordering and counting in the branches and of stock handling in the Distribution Centre, but this causes difficulty in reconciling Branch and Distribution Centre stock figures when these are merged to obtain the overall position of the company's stocks.

(e) Stock balances are stuck every four weeks. This is frequently too long an interval (for example in the summer selling season).

32 The Sales Estimating Department would prefer a system whereby all stock records (or at least those for major products) are on a perpetual inventory basis. Furthermore the system should cater for the reduction of individual stock lines to the appropriate unit of measurement by the most automatic method (e.g., paper products to a square footage basis) for sales estimating and production planning purposes.

33 The Warehouse is divided into the following sections -

(a) Basement	- Paper
(b) Ground Floor	- Bulk Stocks (of all items)
(c) 1st Floor	- Films and Plates
(d) 2nd Floor	- Cameras, Sundry Apparatus and Chemicals

For each order received the goods are looked out, checked by a second operative and assembled for despatch by a third operative.

Orders for Home Market

34 The Wholesale Branch stock counting and ordering schedule (paragraph 12) was mainly devised to satisfy the requirements of the Warehouse. Since it is not easy to switch staff from one section of the Warehouse to another - due to the detailed knowledge of products required - it was desired to obtain an even work load on each section of the Warehouse for all working days of each period. This however clashes to a certain extent with the requirements of the Sales Estimating Department (paragraph 31(d)).

35 When orders for the home market have been looked out and checked, they are placed in a suitable transit container if necessary and sent to Despatch under cover of the order forms.

Orders for Export Market

36 Export orders are dealt with in a similar manner to home market orders except that all goods are invariably packed (in export cases). Furthermore, where the goods ordered from one section of the Warehouse are not sufficient to be despatched on their own, a degree of co-ordination is needed between the foremen of the various sections so that these small items can be amalgamated for despatch in a single container. At present this co-ordination is achieved by a daily meeting of foremen but this is a somewhat cumbersome procedure since it involves a scrutiny and check of all items which have been found too small to justify an individual export container. The present

method has the further disadvantage of taking the foremen away from the floors of their responsibility for a certain period each day.

Despatch Department

37 The ideal would be for the Despatch Department to receive goods for the home market the evening before vans are due to leave on their delivery runs to Wholesale Branches. This ideal also applies to export orders where at present it has been found impracticable to plan orders for despatch in accordance with ship sailing times, resulting in some prolongation of delivery times to export customers. The Despatch Department is thus frequently congested with goods that have to be stored temporarily (to await the next scheduled delivery day). In addition vans do not always carry their optimum load on each run and there are frequent surges of work when goods have to be despatched urgently under special arrangements.

ACCOUNTING AND STOCK RECONCILIATION

38 When orders have been dealt with by the Warehouse, invoice copies are returned to Stock Planning Department who control them and forward them to the Invoicing Department where they are sorted first by branches and then into approximately thirty product groups. The invoices are valued and a total figure for each product group for each branch is compiled for each four week period. These totals are fed to the Accounts Department where sales figures by branches are obtained by dissecting customers invoices in a similar way.

39 Twice each year stock counts are carried out in branches for company accounting purposes. Reconciliations are made between stocks held by branches, receipts of goods by branches and sales to customers. All discrepancies are investigated. Minor movements of stock such as condemnations, withdrawals for internal use and returns from customers are taken into account when stocks are reconciled (cf. paragraph 28).

40 The present system has several disadvantages. Firstly a large amount of clerical work is involved. Secondly the results are not always accurate and dependable due to the fact that sales to customers are made at varying prices according to the type of customer concerned. For example, a sale to an amateur customer would be at a different price to a wholesale trader. As a result, the stock reconciliations carried out twice yearly can only be used as a general guide to the company's stock position and cannot be used as a means of identifying differences to a particular cause. The ideal would be for a separate reconciliation for each item produced by the company and stocked by Wholesale Branches but with present facilities this is not a practical possibility.

Appendix B

PROPOSED REVISED PROCEDURE BASED ON COMPUTER APPLICATION

REQUIREMENTS OF THE PROCEDURE

1 The Group considered that the procedure should satisfy the criteria established in their definition of 'Stores Control' (paragraph 2 of the main report). These establish certain minimum requirements of a revised procedure based on computer applications as follows -

(a) To ensure that adequate stocks of items are available at the right time and in the right place -

(i) From a forecast of anticipated sales for the coming year, factory production levels will be determined. Volume and timing of deliveries from factory to Distribution Centre will be planned, taking into consideration the stocking capacity and the anticipated demands of the various wholesale branches. A continuous review of forecast requirements will be needed so that differences between actual and estimated performance can be calculated or appropriate action to be taken.

(ii) Stocks held in wholesale branches and Distribution Centre will be controlled on a perpetual inventory basis (in practice, it is likely that stock positions will be re-calculated daily).

(iii) Stock control functions will be centralised.

(iv) Maximum and minimum stock levels will be determined for wholesale branches and Distribution Centre. Since the cyclical fluctuation in sales is large, stock levels should be calculated on a period (4 week) basis throughout the year.

(v) Branch stock replenishment orders will be pre-planned so that requirements can be calculated in advance and more closely related to demands on production.

(vi) Timing of deliveries to wholesale branches will be planned to ensure adequate stock levels at points of distribution and to make the most economical use of transport facilities available.

(vii) Details of overstocks will be required - preferably on a weekly basis.

(viii) Information will be required of quantities and locations of items in short supply so that stocks can be distributed in the most effective manner.

(b) To account for all items delivered to stock -

(i) Physical stock counts will be made at intervals and reconciled with perpetual inventory balances; differences will be investigated and accounted for.

(ii) Since stock accounting must take into consideration consumption by sales to customers, it is recognised that this information will be common to stores control, sales invoicing, accounting and cost account procedures. It may be appropriate for this information to be fed to the computer so that consumption is not only identified by product and wholesale branch but also by individual customers, cost and selling prices so that the data can be re-used for these other procedures.

(iii) Information concerning returns, write-offs, wastage and transfers will be required.

(c) To ensure that the minimum amount of the company's resources are absorbed in stock-holding activities -

(i) Stock replenishment must be prompt and frequent so that stock levels can be kept as low as possible. To a certain extent this is dependent on the complexity of production processes but the delay between production and sale must be kept to a minimum.

(ii) Current sales trends will be under constant review so as to adjust production needs in the light of consumer requirements.

SYNOPSIS OF PROPOSED ARRANGEMENTS

2 It is envisaged that a central computer installation would maintain records of stocks, orders, etc. for each branch and for the Distribution Centre. Sales at branches (and sales returns) would be notified to the computer centre daily by copies of sales slips; these would be interpreted and fed into the computer daily to update the stock and expenditure, etc., records.

3 Branch stocks would be replenished weekly following a review by the computer of the stock status of each branch. These reviews would be 'staggered' throughout the week, the review for an individual branch being made two or three days prior to the day on which goods are normally delivered to the branch. Each branch would have a pre-determined standard replenishment order (the standard order quantity may change for different periods in the year); delivery notes for these orders would be prepared away from the computer.

4 For each review, details of the standard order would be fed into the computer but printed output would be restricted to details of items for which some variation of the standard order was necessary according to the computer's calculations (which would take into account, inter alia, minimum and maximum stock figures). Agreed alterations would be made to the pre-printed delivery notes. The standard order (or amended) quantities would be deducted from the Distribution Centre stock and added to the branch stocks in the computer record.

5 Particulars of the receipts into the Distribution Centre and returns from branches would be fed into the computer to update the stock record.

6 Details of pre-determined orders on the Factory for supply to the Distribution Centre would be recorded in the computer record. The computer would review the Distribution Centre stocks and production orders weekly and print out details when some variation to the orders was appropriate according to the computer calculations, for Management action.

7 Periodically, sales statistics analysed under appropriate headings, would be printed out. Similarly financial information (e.g., the value of stocks held) would be provided as required.

INPUT

Orders on Production

8 The following details of orders on production will be fed into the computer record periodically (probably every four weeks) -

(a) Item number
(b) Order number (including period number)
(c) Quantity ordered

Receipts at Distribution Centre from Production

9 The following details will be fed into the computer record to update it when stores are reported as received in the Distribution Centre -

(a) Item number
(b) Order number
(c) Quantity received

Branch Returns to Distribution Centre

10 The following details of returns will be fed in to update the computer record -

(a) Branch code
(b) Item number
(c) Quantity returned

Branch Sales and Returns from Customers

11 The following details of branch sales, as reported on sales slips, will be fed in daily to update the relative branch stock and expenditure figures in the computer record -

(a) Branch code
(b) Date of transaction
(c) Customer code
(d) Channel of sale code
(e) Item number
(f) Quantity sold
(g) Purchase tax code and rate

Details will be printed out if a branch stock falls below the minimum stock figure.

12 By processing the above data all sales information required for sales accounting can be provided, possibly as a subsequent operation.

Branch and Distribution Centre Stock Counts

13 The following details of periodic (every four weeks) stock counts at branches and at the Distribution Centre will be fed in to the computer -

(a) Branch code
(b) Item number
(c) Stock as per computer record
(d) Stock as per stock count

The computer will then print out (for investigation) the item number, stock as per computer record, and stock as per stock count, when the last two items do not agree.

Branch Standard Replenishment Orders

14 Once a week details of the standard replenishment order for each branch will be fed into the computer, together with any variations to standard order quantities recommended by Branch Managers. The computer will update the stock records, printing out details of items only if

(a) stock at the Distribution Centre is insufficient to fulfil the order (in which case the balance will be recorded in the computer as a back order),
(b) stock at Distribution Centre is brought below the Minimum Stock Figure (in which case the order will be fulfilled), or
(c) the supply of the standard order quantity would bring the branch stock above the Maximum Stock Figure (in which case the quantity would be reduced to that which would bring the branch stock up to the Maximum Stock Figure).

15 The standard order for each branch consists of the following details -

(a) Branch code
(b) Item number
(c) Standard quantity

Miscellaneous Input

16 Other miscellaneous forms will be required from time to time, (e.g., for amendment of prices, etc.) but these are not detailed.

COMPUTER RECORD

17 The following details of each item stocked will be maintained in the computer record -

(1) Item number
(2) Cost price
(3) Selling price
(4) Production order number } For each order
(5) Quantity still outstanding } on production
(6) Distribution Centre stock balance
(7) Distribution Centre buffer stock
(8) Distribution Centre minimum stock
(9) Distribution Centre maximum stock
(10) Branch stock balances
(11) Branch minimum stocks
(12) Branch maximum stocks } For each Branch
(13-20) Branch sales by channel of sale in current period
(21-28) Cumulative branch sales by channel of sale
(29) Total original forecast requirements for each period } For each period
(30) Total revised forecast requirements for each period

OUTPUT

Variation of Branch Replenishment Orders

18 The following details will be printed out when an alteration is made to the Branch Replenishment Order for an item -

(1) Branch code
(2) Item number
(3) Standard order quantity
(4) Amended quantity
(5) Code for reason for amendment
(6) Distribution Centre stock (plus outstanding orders on production)
(7) Distribution Centre buffer stock
(8) Branch stock balance
(9) Branch minimum and maximum stocks
(10) Back orders released for execution

Other data (e.g., branch sales by channel of sale) could also be printed out when required.

Variations to Distribution Centre Orders on Production

19 The following details will be printed out when, during the weekly review of Distribution Centre stock, an abnormal situation is revealed (e.g., Distribution Centre stock exceeds Maximum Stock Figure) -

(1) Item number
(2) Original forecast requirement for ensuing period
(3) Revised forecast requirement for ensuing period
(4) Cumulative forecast sales to date
(5) Cumulative actual sales to date
(6) Distribution Centre stock
(7) Orders outstanding on production
(8) Distribution Centre minimum stock

(9) Forecast deficiency/surplus
(10) Back orders outstanding
(11) Details of branch orders (by branch and quantity) where variations from standard have caused a significant change in the forecast requirement for the Distribution Centre stock levels for the ensuing period

Sales and Stock Statistics

20 The following details will be printed out every four weeks -
(1) Item number
(2) Branch code
(3) Channel of sale
(4) Quantity sold
(5) Value of sales

Other Output

21 Data for sales accounting and for financial control will be printed out as required.

CALCULATIONS

22 Variation of Branch Replenishment Orders

(a)	Distribution Centre stock balance
add	Outstanding deliveries from production for current period
store	Result of above sum (a)
(b)	Distribution Centre buffer stock
add	Revised forecast requirements (for ensuing period)
add	Outstanding Branch orders
add	Standard or variation Branch replenishment order
store	Result of above sum (b)

(c) subtract sum (b) from sum (a)

(d) (i) print Items under paragraph 18 if result (c) is negative
(ii) print Items under paragraph 18 if result (c) is positive and then carry out operations (e), (f), (g), (h) and (i) below

(e)	Distribution Centre stock balance
subtract	Standard or variation Branch replenishment order
subtract	Outstanding Branch orders
(f) store	Result of sum (e) as new Distribution Centre stock balance
(g)	Branch stock balance
add	Standard or variation Branch replenishment order
add	Outstanding Branch orders
(h) store	Result of sum (g) as new Branch stock balance
(i) print	Details of outstanding Branch orders to be executed

23 Variations of Distribution Centre Orders on Production

(a)	Distribution Centre stock balance
add	Outstanding orders on production
add	Revised deliveries from production (for next period)
(b) store	Result of sum (a)
(c)	Original Branch replenishment forecast (current period)
add/subtract	Revisions to original forecast
add	Revised forecast (for next period)
add	Distribution Centre minimum stock level

(d) subtract Sum (c) from sum (a)

(e) print Items under paragraph 19 (for forecast deficiency) if result of (d) is negative

If result of (d) is positive -

(f)	Distribution Centre maximum stock level
subtract	Distribution Centre minimum stock level
(g) store	Result of sum (f)

(h) subtract Sum (c) from sum (f)

(i) print Items under paragraph 19 (for forecast surplus) if result (h) is positive

Appendix C

APPRAISAL OF CASE STUDY BY COMPUTER MANUFACTURERS

1 Two computer manufacturers agreed to give an appraisal of the case study and were asked to comment on -
(a) the suitability of the revised procedure for computer application,
(b) whether the procedure was a worthwhile proposition for a computer, and
(c) what the effect of applying a computer would be to the work studied.

REPORT BY COMPUTER MANUFACTURER 'A'

2 The study group's method of working back to first principles is the ideal preliminary for achieving effective computer application. Too many people, even now, fail to realise that complete re-thinking is necessary before a computer can be fully used. The conclusions on the general lines on which this problem should be solved coincide with this manufacturer's.

3 This study of stores control and distribution is one of the applications that a computer should do much better than any other type of office equipment, and should result not only in the obvious advantages of work simplification, reliability and speed, but in the substantial reduction of stock levels through optimisation. The studies have no doubt confirmed that the intricacies are such that it is not possible without a more detailed study to say more than this, but it promises so much that there can be no doubt that further consideration must be given.

4 The next step is to embark upon a fairly detailed study to determine the cost of the computer installation in relation to present methods. Although it will not be possible to calculate the full saving to be achieved - as this will only come with practical experience - the examination should nevertheless give sufficient assurance that the savings will justify the employment of the computer. Any computer manufacturer would be only too pleased to co-operate in such a study but, since it calls for an intimate working knowledge of the problem, this can only be found from within the organization concerned.

5 The best way to achieve this is to send someone from within the organization to a computer manufacturer's course to obtain familarisation with the equipment and knowledge of programming. This is suggested because it is often much easier to acquire a working knowledge of the computer than for a computer manufacturer's employee to learn sufficient of a problem to make a realistic appraisal. However, there would be co-operation during detailed study with one of the computer manufacturer's specialist investigators to determine the right specification for the computer equipment and the form that the input and output should take together with any ancillary equipment that would be required.

6 Assuming that the outcome of such an investigation was satisfactory and an order placed for a computer, there would be an interval before delivery. During this time programs would be finalised and proved stage by stage, preferably at the manufacturer's premises on one of their machines. There may also be an opportunity to run at least a scaled down part of the procedure on one of the manufacturer's machines as a parallel to the existing system so that when the organization's own computer is delivered the installation of the new procedure could proceed with the best chance for a successful change-over.

REPORT BY COMPUTER MANUFACTURER 'B'

(The following assessment has been contributed by a computer manufacturer who produces medium to large scale computers (depending on the ancillary equipment used)).

7 In general the case study and the conclusions reached are adequate for the purpose of assessing feasability of the proposal and enable the advantages of employing a computer on the work to be evaluated.

The equipment suggested for carrying out the work is sufficient for the tasks to be accomplished in a reasonable time, on the assumption that this procedure would not be the only operation to be carried out by the computer. A smaller amount of equipment could be used, however, but this would mean longer operating times and permit no facility for other procedures to be carried out.

BRIEF SPECIFICATION OF EQUIPMENT

8 It is thought that the computer required should consist of -

(a) A central arithmetic and control unit including 384 computer words of high speed storage, each computer word equivalent to 6 alphabetical characters or approximately 9 decimal digits.

(b) In addition to the high speed store, the main working store will consist of a magnetic drum with a capacity of about 4 000 computer words.

(c) Data will be conveyed to the computer by means of punched paper tape which would also be the medium for the computer output.

(d) For the bulk storage of information, five magnetic recording mechanisms would be provided. These mechanisms will be in groups of two and three - each group having its own controlling system.

BRIEF DESCRIPTION OF PROPOSED METHOD

General Principles

9 Centralized Records - Stock at Wholesale Branches will be controlled in detail. This control will be operated centrally in concert with the control of Distribution Centre stocks.

10 Standard Replenishment Orders - Standard replenishment orders for branches will be established and executed automatically. Details of these standard

orders will be included in the information stored within the computer. This will make it unnecessary to incorporate this information with other items of input (as mentioned in appendix B, paragraph 14). It is possible to do this by employing magnetic recording mechanisms but this would not necessarily be the case if other methods of bulk storage were used.

Storage of Data

11 The data required to be stored within the computer is outlined in appendix B, paragraph 17, together with the branch standard replenishment orders. For flexibility it is proposed to have separate film records for Distribution Centre stocks and for Wholesale Branch stocks. For each stock item record per Distribution Centre or Wholesale Branch, the data to be stored will require approximately 32 computer words assuming one computer word for each item of information. The actual storage requirements will be somewhat less if 'packing' of data is resorted to. Assuming records of 6 000 items are required for Distribution Centre and each Branch, approximately 200 000 computer words will be required or approximately two thirds of a reel (one reel holds about 300 000 words). One reel will thus be required for Distribution Centre stock records and the equivalent of 7 reels for Branches.

12 These reels could be processed daily and kept continuously up to date but a considerable amount of computer time would be required with little compensating advantage. It is proposed therefore to retain the basic concept of spreading the branch ordering procedure over a 4-weekly period. The grouping of the commodities to be ordered at any one time by all the branches facilitates a constant level of work for each Warehouse Stock Section throughout the 4-weekly period. This grouping of commodities will mean that not more than the equivalent of 2 reels will contain all the Branch stock records for the commodities to be dealt with in any one week.

13 The basic computer operation to be carried out daily will thus be the revision of the Branch reels and the Distribution Centre reel taking into account the input data. As a matter of general policy revised versions of the records will be produced in new reels rather than over-writing data existing on the reels.

14 As mentioned previously the equivalent of 2 reels will be required to contain the Branch records to be dealt with in one week. As however deliveries are not made to each Branch each day, time will be saved if a separate reel is established for each Branch. It would then be possible for processing to be restricted to only those reels for Branches with deliveries due each day. This will have the advantage that the processing of Branch records can be related to day to day variations in Branch transport runs. Although this will involve 10 actual reels for Branch records these will still represent the equivalent of 7 complete reels.

Computer Operations

15 These will consist mainly of the production of revised versions of the records. Two of the mechanisms will be used each day for reading the Distribution Centre Stock Record and the production of a revised version. Two of the remaining mechanisms will be used in a similar manner for the appropriate Branch Stock Record. The fifth mechanism will be used as a storage medium for data that requires sorting after input and before inclusion in the appropriate Stock Record.

Input

16 The items of input outlined in appendix B, paragraphs 8 - 16, will be dealt with as follows; figures shown are daily averages -

(a) Orders on production (number of items - 500; total characters - 9 000 approximately). This information will be received from the production centres in commodity order and will be added to the Distribution Centre Record without prior sorting. This will be most simply dealt with by storing on an Input Suspense reel for which the fifth mechanism will be used.

(b) Distribution Centre receipts from production (number of items - 5 000; total characters - 90 000). These items will be received in random order and will be required to be fed to the computer in convenient batches for sorting on the magentic drum and stored on the Input Suspense reel.

(c) Branch returns to Distribution Centre and sales and returns from customers (number of items - 13 000; total characters - 385 000). As these items will be received separately for each Branch, and as the details of each Branch will be processed separately, it will be possible for this data to be fed to the computer Branch by Branch and sorted on the drum and transferred to the Branch Record in commodity sequence.

(d) Branch and Distribution Centre stock counts (number of items - 16 500; total characters - 247 500). These items will be punched from stock sheets and will therefore be in commodity code order on the input tape. The Distribution Centre stock counts will be fed to the computer and stored on the Input Suspense reel after the input and sorting of Branch sales and returns. The Branch stock counts will be fed to the computer Branch by Branch and the information read from the input tape item by item as each commodity is dealt with.

Output

17 The items of output outlined in appendix B, paragraphs 18 - 21, will be dealt with as follows -

(a) Variation of Branch replenishment orders and Distribution Centre orders on production - Assuming that standard orders from up to three Branches are dealt with on any one day and that one quarter of total number of possible items (1 500) will be affected, standard orders for 6 000 items will be due (including replenishment of Distribution Centre stocks). Assuming one in ten will be non-standard and that 200 characters will be required for the output information detailed in appendix B, paragraphs 18 and 19, a total of 12 000 characters will require to be printed daily.

(b) Sales and Stock Statistics - These will require approximately 150 000 characters to be printed out each 4-weekly period.

Estimated Operating Times

18 (a) Input

	Characters
Orders on production	9 000
Receipts at Distribution Centre	90 000
Branch returns to Distribution Centre	1 600
Branch sales and returns from customers	868 500
Branch and Distribution stock counts	247 500
Total	1 216 600

Operating time (at an approximate input speed of 150 characters a second) - 2 hours 30 minutes.

(b) Sorting
Receipts at Distribution Centre from production centres
Branch returns to Distribution Centre
Branch sales and returns from customers
Operating time - approximately 45 minutes

(c) Reel Processing
Approximate times for reading and re-writing
Branch stock reels (say 2 per day)
Operating time - approximately 1 hour
(The Distribution Centre Record will be processed at the same time as the Branch Stock Record)
No separate time allowance for the calculations to be carried out by the computer has been made as these will be performed concurrently with the reel processing operations

(d) Output

	Characters
Variations of branch replenishment orders	12 000
Operating time at approximately 25 characters a second - 15 minutes	

(e) Total Operating Time
Grand total of all operating time for computer 4 hours 30 minutes daily. Additional time should be allowed of approximately $1\frac{1}{2}$ hours for the output of stock and sales statistics each 4-weekly period.

Estimated Staff Requirements

19 The staff required are estimated to be as follows:

An engineer and assistant	2
Programmer and assistant	2
Operations supervisor	1
Punch and verifying operators	24
Machine console operator	1
Operator for output printing mechanisms	1
Total staff required	31

20 These staff requirements can be broadly compared with those required to do the work at present. It should be pointed out that a number of the staff required detailed above will be employed on the coding of sales information and the staffing for this task was not included in the original case study. The staff required for this function at present consists of 14 punch and verifying operators so the figures for comparison are as follows -

The number of punching and verifying operators is estimated on the basis of 1 216 600 characters required to be punched each day at an approximate rate of 10 000 characters per hour for which 150 operator hours will be required.

Sales analysis operators	14
Branch stock control staff	24
Distribution Centre Stock Planning Staff	41
Grand total of present staff	79

CONCLUSIONS

It is pointed out that the foregoing sections have been prepared to bring the work of the study group to a practical conclusion. It is stressed however that the authors appreciate that a considerable amount of detail could usefully have been included if time had permitted. The figures quoted for computer

operating times and staff required are sufficiently generous however to cater for any variations to the above appraisal which might become apparent when more detailed planning is embarked upon.

It is felt that from the detailed nature of the study most of the future work involved would be concerned with discussion between management and the staff concerned.

8 - PRODUCTION CONTROL

Two study groups met regularly during the session to consider methods of applying electronic computers to industrial production control. The reports of the two groups have been consolidated into one.

1 No standard routine is at present established for computers, and experience of mechanisation of production control on electromechanical equipment is confined to a few companies. The problem is complex and for each company must be examined in detail.

DEFINITION

2 A definition of the subject is as follows - 'To provide manufacturing schedules and details of material requirements necessary to meet sales forecasts, having regard to maximum machine utilization, minimum manufacturing costs, and achievement'.

3 In the engineering trades which build machines or assemblies of equipment to meet specific orders, the sales forecast or budget is less evident as the primary datum but it enters into the planning of production of parts and standardised sub-assemblies.

4 In the process industries, materials require to be treated or mixed before they are available for high speed manufacture of end-products on automatic lines.

5 There are logical similarities for the systems analyst between these preliminary processes and the production of stocks of components parts for engineering assemblies. The heterogeneous nature of industry makes it difficult to find common ground for a theoretical approach to the subject, but the similarities of the problems became apparent when the two following specific examples are considered.

Function of Production Control in a Light Engineering Company

6 The main feature of the problem here is the large number of different types of product made and the detailed adjustments necessary when sales demands are changed, which happens frequently. These changes affect the following control operations -

(a) Machine Loading;
(b) Purchasing materials ahead of manufacturing schedules;
(c) Inventory Control with particular reference to keeping stocks at a minumum safe level;
(d) Provisioning of labour;
(e) Sub-contracting on other companies;
(f) Progressing through production operations to meet earliest delivery dates;
(g) Costing and accounting.

The following is a typical sequence of events-
(a) Order received in Factory;
(b) Order broken down into individual components;
(c) Analysis made with present stock and cover issued;
(d) Bought out components ordered and delivery requested in monthly quantities one month in advance of Sales Programme;
(e) Shortages of manufactured parts passed to Raw Material Control for checking material stocks and ordering if necessary (delivery requested in monthly quantities one or two months in advance in accordance with manufacturing time);
(f) Orders issued to cover four months stock;
(g) Analysis made to ascertain parts required month by month to meet Sales Programme;
(h) Instructions issued to Stores to appropriate sets of parts each month in line with Sales Programme;
(i) When sets are complete they are issued for assembly.

Function of Production Control in a Process Industry

8 The main point here is the difficulty of distributing a small number of perishable products over the whole country, the stock life of the product at the retailer's premises being limited.

9 The second major difficulty is in programming a continuous process which has several severe quality control restrictions and a fluctuating sales demand. The basis of a typical production control system is as follows -

(a) Basic plan for one year prepared by sales department every six months as a forecast for materials procurement (broken down to show est-

imated requirements per quarter);
(b) Production plan prepared monthly, about the middle of previous month, showing estimated production required per week of each line, based on forecast of sales and review of stocks held throughout the country; on the basis of this plan raw materials are called forward from bulk stores (which usually hold about 10 weeks stock; about one weeks supply can be held at the factory);
(c) On Thursday preceding each week, orders received from distributors of requirements for following week line by line; instructions issued to the factory having regard to -
(i) transport available to any one region on certain days per week,
(ii) shelf-life of product,
(iii) maximum number of days finished stock (all lines) factory can hold,
(iv) maximum number of lines packaging plant can pack at any one time,
(v) number of hours lost in production when a change of line occurs,
(vi) normal working hours (e.g., five 24 hour days may normally be worked with the option of up to a further 24 hours overtime), and
(vii) proportion any one line bears to total production (e.g., two principal lines account for about 60-70%; the remaining 30-40% is about evenly divided over a dozen lines).

10 There are a number of (say 15) main raw materials all of which have to be pre-treated in batches. The plant can pre-treat about 30 batches per day and it can be sub-divided to treat four different materials at any one time. There is intermediate storage for the pre-treated materials but no batch may be stored for more than x days. The final product is a blend of, say, ten of these raw materials.

SUMMARY OF DISCUSSIONS

11 It was agreed that these two cases were typical of control problems, although the degree of importance of individual functions varied considerably.

12 The main factors which a computer application would have to cover appear to be -
(a) Unstable sales demands,
(b) Short delivery dates,
(c) Machine loading and utilization,
(d) Forward ordering of parts or raw materials,
(e) Distribution,
(f) Control of work in progress stocks at each point in the production process,
(g) Quality Control,
(h) Varying production cycle times, and
(i) Rapid collation of information from various records relating to the above functions when production programmes have to be amended.

CONCLUSIONS

13 Production Control problems are basically the same for all industries but they will differ in individual cases according to the requirements of the various activities to be served by the Production Control function as a whole. In studying these problems from the point of view of computer application the function which is most important should first be analysed. Where several interlocking functions are involved, they should be dealt with one at a time each with its flow chart and document organisation. After all functions have been thoroughly investigated and a system evolved for each, integration may be considered.

9 - COMPARATIVE DATA ON MACHINES AVAILABLE IN THE UNITED KINGDOM FOR CLERICAL USERS

DEFINITION OF SUBJECT STUDIED

1 The Group took the following terms of reference -

To study comparative data on machines available in the United Kingdom for clerical users and to submit a report on the findings.

2 These terms of reference were defined by the group as follows: -

(a) 'Machines Available in the U.K.' - to be restricted to machines manufactured in the United Kingdom, or by firms who have established sales organizations to sell foreign machines here.

(b) 'Machines for Clerical Users' - all machines for processing commercial data for accounting, production control, market research, etc., purposes and not restricted to purely scientific or technical applications.

(c) 'Comparative Data' - the provision of detailed machine specifications to provide, if possible, valid comparison between the various machines.

(d) 'Available' - now in use, or capable of being delivered and giving effective service to customers now or within three years from January 1957.

3 Because of the relatively short time available to the Study Group it was not possible to cover the entire field. It was therefore decided to limit the study of equipment to basic computer machinery, leaving aside variations of input and output equipment which were being considered by a separate Study Group (see Report 10).

4 To economise in time and effort it was decided to review the various surveys in the computer field, and to combine information contained therein with information made available by members of the Group and by manufacturers.

5 Specifications so obtained were drawn up on a comparative basis, and discussed in detail. Considerable effort was expended in trying to arrive at a formula which would enable the Group to express an opinion on the relative suitability of particular machines to comparable commercial applications but this was found to be impracticable at the present time.

GENERAL COMMENTS AND CONCLUSIONS REACHED

6 The Group was handicapped in carrying out its task because there are not enough commercial applications of electronic digital computers to provide the practical experience which it was felt to be desirable if the report was to give guidance to potential users. The Group has concluded that at the present state of knowledge of the application of computer techniques to commercial data processing in the U.K. it would be dangerous for it to express any opinions regarding the suitability of any particular computer for any particular commercial application.

7 The Group therefore decided that it would restrict its report to the preparation and submission of the specifications given in the Appendix. These specifications are of limited value since the implications of the various machine functions relative to machine speed and logical construction are dependent upon the application for which the computer is to be used. Comparative data for machines is only of any real importance when allied to application.

In addition to the machines "currently available" (as defined in the above Report), several others have been included, although now superseded, as they are in current operation and mark an important stage in the development of later machines. - Ed.

APPENDIX

MACHINE SPECIFICATIONS PREPARED AND CONSIDERED BY THE STUDY GROUP

Manufacturer	Report No.	Machine
British Tabulating Machine Co. Ltd.	1	HEC 4 (Type 1201)
Burroughs Adding Machines Ltd.	2	E.101
Elliott Brothers (London) Ltd.	3	402E
	4	402F
	5	403
	6	405
English Electric Co. Ltd.	7	DEUCE
Ferranti Ltd.	8	Mark I & Mark I*
	9	Mark II (Mercury)
	10	Pegasus
International Business Machines (U.K.) Ltd.	11	IBM.650
	12	IBM.704
	13	IBM.705
	14	IBM.709
Leo Computers Ltd.	15	LEO II
Powers-Samas Accounting Machines (Sales) Ltd.	16	PCC
Remington-Rand Ltd.	17	UNIVAC I
	18	UNIVAC II
	19	UNIVAC 120
	20	UNIVAC File Computer

(1)

HEC 4 (Type 1201) GENERAL PURPOSE COMPUTER - (British Tabulating Machine Company Limited)

1 - General Description

Medium size, general-purpose digital computer, orthodox chassis construction. Developed from the Birkbeck College APEC (X) and HEC 2 series.

2 - Uses

Flexible and simple in logical design and order code. Serial mode of digit working. Primarily used for commercial work. Automatic conversion to binary during input. Single comprehensive order codes are available for the conversion for output, multiplication and division.

3 - Input-Output

(a) Input - from punched cards fed at 85 cards per minute. Between 48 and 52 columns can be fed into the computer. (The actual limit is set by the input conversion unit which has a capacity of 4 x 40 bits). Storage unit capacity is 24 digits but may be increased to 64 digits.

(b) Factors can be read at different stages so that some calculations can be made and the answers be available before a card reaches the point at which it is normally read for printing purposes. In this way, details from the card and calculated factors can be printed simultaneously to save time and reduce the amount of data which needs to be read from the cards and stored with the machine.

(c) If cards are punched in binary form (e.g. constant factors, computed brought forward items or program steps) there can be up to 12 x 40 bit numbers in each card which can be read in the same time as a normally punched card.

(d) Output - at 85 print lines per minute, 100 cards per minute. 64 columns from computing unit plus 12 or 24 from input unit. Storage unit capacity as for input. Cards can also be punched containing up to 12 x 40 bit binary numbers.

4 - Quick Access Stores

Two each of 1 x 40 bit word named Q and B.

5 - Magnetic Drum

64 tracks each of 16 words = 1 024 words = 40 960 bits. There is a read/write head for each track. Drum speed is 3 000 r.p.m. There is also available a larger drum containing 4 080 words on 255 tracks.

6 - Method of using storage

(a) Program steps and computing data are held on the drum. Access time varies from instantaneous to a maximum of 18.75 milliseconds.

(b) Q and B will have data or program steps transferred to them for repetitive use at a higher rate than permitted by the drum.

(c) HEC is an optimum coded machine for which the programmer draws his program to avoid waiting either for the next instruction or the next piece of data.

7 - Instructions

(a) A word consists of 40 bits, being either an instruction or a number of 39 bits and a sign bit.

(b) An instruction takes the form -

Operand Address				Function	Next Instruction Address				Optional Stop	Shift-Count
Q	B	Track	Word		Q	B	Track	Word		
1	1	6	4	5	1	1	6	4	1	7

The remaining three positions are spare.

(c) An instruction is set up in one word time and obeyed in the next. In deciding how long any function will take, allowance must be made for the single word time during which the machine prepars to carry out the function.

8 - Speeds

The pulse rate is 38.4 kilocycles per second. Word time is 1.25 milliseconds.

9 - Functions

(a) The arithmetic unit consists of an adder and two 40-bit registers A and M. All computing is carried out between these, B, Q and the Drum.

(b) Most functions occupy one word time (i.e. 1.25 milliseconds). An average multiplication takes 22.5 milliseconds and an average-sized division about 30.0 milliseconds.

10 - Production

In series production at Stevenage, Hertfordshire. Delivery 2 years from order.

11 - Price

£30,000 - £33,000 complete with punched card input unit, printing output unit and punch output unit.

12 - Weight

54 hundredweight.

13 - Power Consumption

8 kilowatts.

14 - Floor Area

For housing and operating the equipment, an area of about 300 square feet is required. Special ventilation for heat dissipation may be desirable.

(2)

E.101 - (Burroughs Adding Machines Limited)

1 - General Description
Desk-size, low cost, programme controlled digital computer.

2 - Uses
Commercial, scientific.

3 - Construction
Designed to be available in the general office and not in a special computing centre. Size 5 feet by 3 feet.

4 - Storage capacity
Magnetic drum - 220 12-digit words plus sign.

5 - Input
Conventional keyboard accounting machine. Punched tape unit (optional).

6 - Output
Semi-gang page teleprinter.

7 - Speeds
(a) Input - manual speeds. Output - 24 digits per second.

(b) Addition time - 60 milliseconds including access time.

(c) Multiplication and division - 250 milliseconds including access time.

8 - Code
(a) Pulse - coded decimal.

(b) Manual program set up by dropping pins into a series of control boards - up to 128 programme steps. Program can also be presented to computer by punched paper.

(c) Word length - 12 decimal digits.

9 - Production
Manufactured only in U.S.A. Will be available shortly in U.K.

(3)

402E - (Elliott Brothers (London) Ltd.)

1 - General Description
Small, medium speed, general purpose, digital computer.

2 - Uses
Scientific and technical

3 - Construction
Packaged.

4 - Storage Capacity
Magnetic drum - 4 992 words. Nickel delay lines (17, including accumulator).

5 - Access Times
Magnetic drum - to 1 024 words (8 tracks) 13 milliseconds and to remainder 26 milliseconds.

6 - Input
Punched Cards (65 or 80 column) and punched paper tape with photo-electric reader.

7 - Output
Electric typewriter or punched paper tape.

8 - Speeds
(a) Input - tape at 180 characters per second or cards at 400 cards per minute. Output - 25/33 characters per second with punch.
(b) Digit time - 3 microseconds. Addition time - 204 microseconds.
(c) Multiplication - 3.366 milliseconds. Division - 3.366 milliseconds.

9 - Code
(a) Binary, serial. Word length - 32 binary digits.
(b) 1 + 1 address code (optionally optimum coded). Addresses can be modified, using 7 B-lines.

10 - Production
7 machines have been delivered.

11 - Price
£25,000.

12 - Delivery
6-9 months.

(4)

402F - (Elliott Brothers (London) Ltd.)

1 - General Description

A variant of the 402E computer. All speeds are identical. Main difference is that all arithmetic operations are carried out on fixed or floating binary point under program control.

2 - Price

£35,000.

(5)

403 - (Elliott Brothers (London) Ltd.)

1 - General Description

Medium to large, medium to fast, general purpose, digital computer.

2 - Uses

Scientific and scientific data-processing.

3 - Construction

Packaged.

4 - Storage Capacity

(a) Magnetic disc - 16 384 words

(b) Nickel delay lines - 512 words (127 four-word lines and 4 one-word lines including accumulators).

(c) Magnetic tape units - 3.

5 - Access Times

Magnetic disc - 32.5 milliseconds (maximum). Computing store - 300 micro-seconds.

6 - Input-Output

Punched paper tape and magnetic tape via ancillary store.

7 - Speeds

(a) Input - magnetic tape at 2 000 characters per second, or paper tape at 180 characters per second.

(b) Output - magnetic tape at 2 000 characters per second.

(c) Digit time - 3 microseconds. Addition time - 102 microseconds.

(d) Multiplication - 1.734 milliseconds. Division - 3.468 milliseconds.

8 - Code

(a) Binary, operating in range $2 \leqslant x < 2$, serial.

(b) Word length - 34 binary digits. Order length - 17 digits (i.e. two orders per word).

(c) 1 address code. Addresses can be modified, using 3 B-lines. 31 instructions, including 6 branch orders.

9 - Production

This machine was custom-built for an Australian organisation and delivered during 1955.

(6)

405 - (Elliott Brothers (London) Ltd.)

1 - General Description
General purpose, data-processing digital computer.

2 - Uses
Commercial data-processing and scientific applications.

3 - Construction
The computer is of unit construction, consisting of a system centre (A), which is a complete computer in itself, to which one or more of the following units can be added:
B-Monitoring and control console
C-Teleprinter tape reader
D-Punched card input
E-Magnetic drum storage unit
F-Magnetic disc storage unit (2 types)
G-Magnetic film unit
H-Teleprinter tape output
I-Electric typewriter output
J-Magnetic film output
K-Line-at-a-time printer
L-Compiler
M-Line assembler
N-Additional immediate-access storage (16 words)

4 - Storage Capacity
A-128 words (addition of other units increases to 512 words) working storage.
E-4 096 words.
F-16 384 or 32 768 words.
G-300 000 words per 1 000-feet reel.

5 - Access Times
Nickel delay lines - 1 530 milliseconds (maximum). Magnetic drum - 32.5 milliseconds (maximum). Magnetic disc - 45.5 milliseconds (maximum).

6 - Input
Combinations of items C, D, G & M.

7 - Output
Combinations of items H to K and M (As many input/output units as are ever required working simultaneously or switched).

8 - Speeds
(a) Input - C at 180 characters per second, D at 600 cards per minute, and G at 2 400 characters per second.

(b) Output - H at 25 characters per second, K at 150 lines per minute (92 characters per line), I at 20 characters per second, and J at 300 characters per second.

9 - Code
(a) Binary, serial. Word length - 32 binary digits. Order length - 16 digits, i.e. two orders per word.

(b) 1 address code, with two different classes of order operating concurrently. Addresses can be modified by use of 2 B-lines. Sequence control modification.

(c) Addition time - 102 microseconds. Multiplication & Division - 3.264 milliseconds.

10 - Production
1 produced and operating in 1956. 2 produced and operating April 1957. 5 at present under construction.

11 - Price
According to specification

12 - Delivery
12-18 months.

13 - Servicing Time Including Test Program
1 hour per day.

14 - Air Conditioning

None. There are temperature limits for working.

15 - Cost of Maintenance
5% of capital cost per annum or £2500 (whichever is the greater) on the electronic equipment purchased. Maintenance staff included in 5% charge. Alternative schemes are available.

(7)

DEUCE (Digital Electronic Universal Computing Engine - (English Electric Company Limited)

1 - General Description

Medium size, general purpose digital computer of orthodox chassis construction. Extremely fast Serial mode of digit working. Developed from the "Pilot ACE" designed by National Physical Laboratory.

2 - Uses

Completely flexible and simple in logical design and order code. Primarily used for scientific and engineering calculations. Everything has to be programmed including input/output conversions from normal alpha-numerical to pure binary.

3 - Input-Output

(a) Hollerith punched cards input 200 cards a minute, output 100 cards a minute. Normal punching convention may be used. Program must be in binary. Only 32 columns (21-52) can be read or punched. This will be doubled in the near future.

(b) Magnetic tape equipment is in the final stages of development. As an interim measure American tape decks will be used. Order code for this has been produced and appropriate logical design.

4 - Quick Access Stores

All QAS are temperature controlled mercury delay lines -

12 of 32 words	= 384 words	=	12 288 bits
2 of 4 words	= 8 words	=	256 bits
3 of 2 words	= 6 words	=	192 bits
4 of 1 word	= 4 words	=	128 bits
Total QAS	= 402 words	=	12 864 bits

5 - Backing Store (Magnetic Drum)

256 tracks of 32 words = 8 192 words = 262 144 bits. There are 16 reading heads which move together to 16 reading positions (16 x 16 = 256, i.e. the number of tracks). Drum speed is 6 500 r.p.m.

6 - Method of Using Storage

(a) The backing store contains program and data not immediately required for computation. Complete tracks of information can be brought into QAS as required. In this sense there is no "Access Time" to information on the drum as although transfer takes from 13 to 48 milliseconds (the latter with head shift) for one track of 32 words, this takes place concurrently with computation.

(b) Average Access Times to the QAS are

32 word stores	- 496	microseconds
4 word stores	- 48	"
2 word stores	- 16	"
single word stores	-	Nil

(c) DEUCE is an optimum coded machine (i.e. programs are designed to avoid waiting either for the next instruction or the next piece of data). Theoretically a perfect programme would have no waiting time as it would use the available "stepped storage" progressively; this is of course not attained in practice.

7 - Instructions

(a) A "word" consists of 32 bits being either an instruction or a number of 31 binary digits and a sign digit. An instruction is of the following form -

	Next Instruction Source	Source
No. of bits Address	3 bits (0-8)	5 bits (0-31)

Destination	Wait	Timing	Other
5 bits (0-31)	5 bits (0-31)	5 bits (0-31)	9 -

(b) The nine "other" bits are 1 "Stop/Go", 2 Characteristics, 4 "Joes" (Instruction modifications) and 2 Spares. This is therefore a modified two-address code.

8 - Basic Speed

(a) Pulse rate is 1 megacycle per second (i.e. a digit is generated each microsecond). Minor Cycle = Word Time = 32 microseconds. Major Cycle = 32 Word Times = 1 millisecond (approx).

(b) An instruction is set up in one word time and obeyed in the next (i.e., it is a two beat machine).

9 - Functions

(a) Functions are obtained by transfers to

functional destinations - e.g. 14-13 Contents of T.S.14 Acc.; 15-25 Contents of T.S.15 added to Acc.

(b) There are three accumulators of this kind, two of which can be joined together for double length arithmetic, particularly of course multiplication and division.

(c) Functions are -

Add, subtract, Test Logical "&", Logical "≠"	64 microseconds
Shift up (X 2), Shift down (÷ 2)	32+32 " per digit shift
Multiplication and Division	2 milliseconds (approx.)

(d) It is important to note that multiplication and division can proceed concurrently with other computation so that these operations do not slow the machine down too much.

(e) Though it is difficult to give an average speed for all operations in a programme, it is something of the order of twelve instructions per millisecond.

10 - Production
Regular production now flowing at firm's works at Kidsgrove. 10 in use at May 1957.

11 - Delivery
About six months.

12 - Price
About £43,000 with punched card input/output.

13 - Weight
46 hundredweight.

14 - Power Consumption
9 kilowatt (no special ventilation for head dissipation is necessary, but it may be desirable).

15 - Floor Area
90 square feet.

16 - Servicing Time Including Test Programme
2 hours daily.

17 - Air Conditioning
No air conditioning equipment provided. 2000 cubic feet of air per minute is desirable.

18 - Cost of Maintenance Staff
Included in the cost of the computer is the training of a mathematician as a programmer and the training of a maintenance technician. Higher National Certificate or equivalent required.

19 - Cost of Maintenance
Estimated annual component replacements approximately £300.

(8)

MARK I AND MARK Ix - (Ferranti Ltd.)

(Note - Mark I is sometimes called 'Manchester'; Mark I Star is a later model).

1 - General Description
Large, general purpose digital computer.

2 - Uses
Scientific.

3 - Construction
Conventional chassis construction.

4 - Storage Capacity
(a) Magnetic drum - equivalent to about 200 000 decimal digits

(b) Cathode ray tubes - 390 words

5 - Access Times
Magnetic drum - 25 milliseconds (max.). Cathode ray tubes - 240 microseconds.

6 - Input
Punched paper tape.

7 - Output
Page-printing teleprinter, punched paper tape, or line-at-a-time printer.

8 - Speeds
(a) Input - 200 characters per second. Output on teleprinter at 7 characters per second, on paper tape at 33 characters per second, and on printer at 150 lines per minute.

(b) Digit time - 10 microseconds. Addition time - 1.2 milliseconds.

(c) Multiplication - 2.16 milliseconds

9 - Code
(a) Binary, serial. Word length - 20 or 40 binary digits.

(b) 1 address code, 2 orders in one word. Addresses may be modified, using 8 B-lines

(c) Division has to be specially programmed.

10 - Production
No longer in production. 9 have been sold.

11 - Price
£85,000 approx.

(9)

MARK II (MERCURY) - (Ferranti Limited)

1 - General Description
Large, high speed, general purpose digital computer.

2 - Uses
Scientific and technical.

3 - Construction
Chassis construction with built-in refrigeration.

4 - Storage Capacity
(a) Magnetic drums (4) - 16 384 words (a further 4 drums can be added).

(b) Magnetic cores - 1024 words.

5 - Access Times
Magnetic drums - 18 milliseconds (max.). Magnetic cores - 10 microseconds for 10-digit group.

6 - Input-Output
Punched paper tape; magnetic tape is being developed.

7 - Speeds
(a) Input - 200 characters per second.

(b) Digit time - 1 microsecond. Addition - 180 microseconds.

(c) Multiplication - 360 microseconds.

8 - Code
(a) Binary, serial. Floating binary point. Word length - 30 + 10 digits.

(b) 1 address code - 20 digits. Addresses can be modified.

(c) Division has to be specially programmed.

9 - Production
First machine not yet delivered, but 9 orders received.

10 - Price
£100,000 approx. for complete installation.

11 - Delivery
18 months.

(10)

PEGASUS - (Ferranti Limited)

1 - General Description

Medium size, general purpose digital computer of package construction. There are 444 packages of plug-in units of 21 different types, but 375 of the units are of only six types.

2 - Uses

Flexible in logical design with comprehensive and powerful order code. Designed originally for scientific and engineering calculations, but with suitable input/output equipment has been used and sold for commercial work. Input/output conversions from alpha-numerical to pure binary have to be programmed, but there is a program on the magnetic drum to do this. Can handle alphabetical information. The layout for output printing has also to be programmed.

3 - Input-Output

(a) Input is on 5-channel punched paper tape at 200 characters a second. Tape prepared from key-board machines such as Creed Perforator. Both data and program on paper tape, punched in normal decimal or alphabetical form.

(b) Output is on 5-channel paper tape at 33 characters a second, fed to a teleprinter which prints at 7 characters a second. Computer is free once it has punched tape, it is not held up by a slower speed of teleprinter. Possible to take paper tape and print on a teleprinter away from computer.

(c) Magnetic tape has been fully tested at Ferranti's London Computer Centre. At first using Electro-Data (of America) Tape Decks suitably modified, with ½" plastic tape, 2400 feet long, with input and output speed of 9 250 characters a second (i.e. 123 characters to the inch, tapes move at 75 inches a second). One Buffer store of 32 words, filled from tape in approximately 56 milliseconds. Data, however, must still be converted from decimal to binary and vice-versa if any arithmetic is to be performed on it, so full speed of the tape may not be achieved. Conversion approximately 3-4 milliseconds per character. Standard installation will probably consist of four tape units.

(d) A printer from magnetic tape is being developed with Powers-Samas at 300 lines a minute, but until this is ready the Bull Printer at 150 lines a minute will probably be used.

(e) A punched card to magnetic tape converter and vice-versa has been developed to enable computer to be used in existing punched card installations. Converter works at 200 cards per minute to magnetic tape, and at 100 cards per minute from magnetic tape, for 80 column cards. The first converter uses Hollerith cards.

(f) Direct punched card input/output is expected to be developed with Powers-Samas.

4 - Quick Access Store

(a) All quick access stores are nickel delay lines in packaged units which do not present temperature control problems. All lines are single word stores with instantaneous access. Word consists of 42 bits (39 used by programmer), equivalent to 11 decimal digits plus sign. 55 nickel delay lines, divided into 7 accumulators (i.e. storage lines with special arithmetic properties) and 48 ordinary storage lines or registers.

(b) Method of working is generally to bring program and data from drum to fast store, work through instructions, bring fresh program and data from drum to fast store, work through instructions, bring fresh program from drum. Word time is 126 microseconds, and most simple arithmetic operations are carried out in 2½ word times (actually two operations in 5 word times).

5 - Backing Store (Magnetic Drum)

(a) 40 tracks each of 128 words (=5 120 words). 4 096 are available for program and data, while 1 024 are reserved for input/output sub-routines and engineer's test programs. Drum speed is 3 720 r.p.m. and there is a reading head for each track thus there is no track switching.

(b) Revolution time is 16 milliseconds,

thus average access time to any word is 8 milliseconds.

6 - Method of Using Storage

(a) Data and program on drum usually transferred to fast store in blocks of 8 words though single word transfers also performed. Block transfer will on average take about 9 milliseconds (8 milliseconds waiting for drum to revolve and .126 milliseconds for each word transferred). If consecutive blocks of 8 words are transferred there is, of course, only 8 milliseconds waiting time for first block and no waiting time for the rest. While transfers are proceeding, no computation can be carried out.

(b) Once in fast access store, average access time to information is nil.

7 - Programming

(a) Instructions in Pegasus are generally obeyed one after the other and there is sufficient room in fast access store to hold many instructions; no need for optimum programming. Each word contains 2 instructions, thus block of eight words contains 16 instructions.

(b) Instruction is generally of the following form -

Address of Register	Address of Accumulator	Function	Modifier
7 bits	3 bits	6 bits	3 bits

(c) This is therefore a two-address code, with one of the addresses limited to an accumulator.

(d) The modification facility allows large cycles of operations to be performed with the minimum of instructions and time. Any of the 7 accumulators can be used for holding the modifier.

(e) There are some 48 functions, including addition, subtraction, multiplication, division, shifts, double-length working, logical operations and jumps (discriminatory orders). There are 8 discriminatory orders.

8 - Speeds

Pulse rate is $\frac{1}{3}$ megacycle (i.e. a digit is generated every 3 microseconds). Assuming all data is in fast store -

Add, Subtract, Transfer, Test, Logical Operations	= 0.3	millisecs.
Multiplication	= 2.0	"
Division	= 5.5	"
Shifts	= 0.3	" per digit shift

Other operations cannot be performed during multiplication and division.

9 - Production

Production line at new West Gorton factory in Manchester, up to 7 machines being worked on at one time. First Pegasus installed at the London Computer Centre; 5 others have been delivered to customers. More than 20 orders and letters of intent received.

10 - Price

About £45,000. Magnetic Tape plus Punched Card plus Printing Equipment extra. Complete commercial installation probably around £100,000.

11 - Delivery

18 months.

12 - Power Consumption

12 kilowatts (no special ventilation for heat dissipation in existing installations, but when other units such as magnetic tape and printers are used, it will be desirable).

13 - Servicing Time Including Test Programme

1½ hours daily.

14 - Air Conditioning - No. Dissipates about 7 kilowatts so exhaust fan is desirable.

15 - Cost of Maintenance Staff

Senior programme engineer and junior maintenance engineer required.

16 - Cost of Maintenance

£500 per annum (approx.).

(11)

IBM 650 - (International Business Machines (U.K.) Limited)

1 - General Description
Medium size, general purpose, digital computer.

2 - Uses
Commercial and scientific.

3 - Construction
Designed to be an integral part of a data processing system.

4 - Storage Capacity and Access Times

	Capacity	Access Time
Magnetic Drum	2 000 wds.	2.4 ms. (ave.)
Accumulator and Distributor	3 words	.096 ms.
Immediate Access Storage	60 words	.096 ms.
Disc Memory Storage ⁂	2 400 000 wds.	600 ms. (max.)

⁂ Automatic optimum programming can reduce these lines to zero.

5 - Input-Output

		Input	Output
533 Card Read Punch	(3⁂)	200 cpm	100 cpm
537 " " "	(3⁂)	155 "	155 "
407 Accounting Machine	(3⁂)	150 "	150 lines per min. (120 chars.)
727 Magnetic Tape Units	(6⁂)	15 000 chars. per second	(same as input)
838 Inquiry Stations	(10)	Typed Data	Printed

Any combination of up to a total of 3 of these units ⁂ is possible. High speed printers which print up to a 1000 lines a minute are available for off line printing.

6 - Speeds
(a) Addition - .76 milliseconds

(b) Multiplication - 12 milliseconds (10 x 10 digits). Division - 16.2 milliseconds (20 ÷ 10 digits).

(c) Logical Decision - .44 milliseconds.

7 - Code
(a) Binary coded decimal. Word length - 10 decimaldigits and sign.

(b) 1 + 1 Address Code (optimum coded).

(c) A floating point arithmetic device and indexing accumulators are available.

8 - Production
By the end of 1956 over 600 had been installed and over 1200 were on order. 650's are being manufactured in the U.S.A., U.K. and elsewhere. Two are installed in U.K.

9 - Price
Rental - £18,000 per year upwards. Sale - £70,000 upwards.

(12)

IBM 704 - (International Business Machines (U.K.) Limited)

1 - General Description
Large, general purpose data-processing digital computer.

2 - Uses
Scientific.

3 - Construction

Unit	No.	Purpose
704	1	Central Processing Unit
733	2	Magnetic Drum
723	10	Magnetic Tapes
721	2	Card Punch
711	1	Card Reader
716	1	Printer
740	1	Cathode Ray Tube

4 - Storage Capacity
(a) Magnetic Core 4 096, 8 192 or 32 768 words. Access time - 12 microseconds.

(b) Magnetic Drum - 8 192 or 16 384 words. Access time - 13 milliseconds.

(c) Magnetic Tape - 5 million characters.

5 - Input-Output
Magnetic tape, punched cards, printer, cathode ray tube (visual and photographic).

6 - Speeds
(a) 711 - 250 cards per minute,
721 - 100 cards per minute,
716 - 150 lines of 120 characters, alphameric, and
723 - 15000 characters per second.

(b) Addition time - 24 microseconds.

(c) Multiplication time - 24 to 240 microseconds. Division time - 24 to 240 microseconds.

7 - Code
(a) Binary (input/output alpha/decimal), parallel. Word length 36 binary digits (input/output 10 decimal digits).

(b) Floating binary point. Single Address Code. Address may be modified.

8 - Production
For all machines of the 700 series, 320 had been ordered by late 1956 and over 100 had been installed.

9 - Price
Selling Price - £500000 upwards. Rental Price - £100000 a year (upwards).

(13)

IBM 705 - (International Business Machines (U.K.) Limited)

1 - General Description
Large, general purpose data-processing digital computer.

2 - Uses
Commercial data-processing.

3 - Construction
Consists of a central processing unit, to which may be added any number of input and output units.

4 - Storage Capacity
Magnetic Core - 20 or 40 thousand characters (alphabetic or numerical). Magnetic Drum - 60 000 characters per drum (up to 30 drums possible). Magnetic Tape - 5 million characters per reel. Accumulator - 256 positions. Auxilliary storage - 256 positions.

5 - Access Times
Magnetic Core, 17 microseconds. Magnetic Drum, 8 milliseconds.

6 - Input-Output

	Unit	Speed
714/719	Card Reader and Control Units (100)	150 cards per minute
722/758	Card Punch Control Units (100)	100 cards per minute
727	Magnetic Tape Units (100)	15000 characters per sec.
(on 705 console)	Typewriter (1) (from memory)	600 characters per min.

Off line printing from Magnetic Tape on high speeds printers up to 1000 lines a minute is possible.

7 - Speeds
(a) Addition Time - 120 microseconds.

(b) Multiplication Time - .08 milliseconds (5 digits x 5 digits). Division Time - 1.8 milliseconds (6 digits ÷ 4 digits).

8 - Code
Binary coded decimal. Word length variable.

9 - Price
Rental - £110,000 a year upwards. Sale Price - £500,000 upwards.

(14)

IBM 709 - (International Business Machines (U.K.) Limited)

1 - General Description
Large, general purpose data processing digital computer.

2 - Uses
Scientific.

3 - Construction
Reading, writing and computing function independently by means of a Data Synchronizer, so that no time is wasted during which one function is awaiting the completion of another.

4 - Storage Capacity
(a) Magnetic Drum Storage - up to 16 384 words

(b) Magnetic Core Storage - 327 000 number digits or 196 000 alphanumeric digits (approx.).

5 - Access Time
Magnetic Drum - 12 microseconds. Magnetic Core - 13 milliseconds.

6 - Input-Output
Magnetic Tape, punched card, printed, cathode ray tube (for visual and photographic purposes). 711, 721, and 716 as on 704. 729 Magnetic Tape Unit; data which is written on to the tape is automatically checked through a record set of reading heads.

7 - Speeds
(a) Straight operation times no longer provide a useful guide to the 709's capabilities. Programme time is greatly speeded by 3 index registers, a larger vocabulary of instructions and the design of the computer.

(b) Addition - 24 microseconds; floating point 100 microseconds.

(c) Multiplication and division - 24 to 240 microseconds; floating point 200 microseconds.

8 - Price
Rental: £120,000 upwards per year. Sale price: £600,000 upwards.

(15)

LEO II (LYONS ELECTRONIC OFFICE) - LEO Computers Limited.

1 - General Description
High speed, general purpose, data-processing, digital computer.

2 - Uses
Clerical and mathematical.

3 - Construction
Unit, with packages for common electronic assemblies.

4 - Input-Output
(a) Input - 80-column punched cards and/or 5-channel punched paper tape. Cards can be punched according to binary or decimal notations. If required, binary/decimal system, in which binary equivalent is punched separately for each decimal unit, can be used. Using binary system it is possible to carry equivalent 48 four-decimal digit numbers on each card. The reader will deal with 200 cards a minute irrespective of the number of digits punched on each card. Tape is read at a rate of 200 characters a second. Up to 4 input channels can be used simultaneously.

(b) Output - Printed results direct from the computer at speeds of up to 300 lines of 108 alpha-numeric characters a minute, according to type of printer used. Card punch produces 100 binary or decimal cards a minute. Up to 4 output channels can be be used simultaneously.

(c) Magnetic tape linkage arrangements and a document reader are under current development.

5 - Quick Access Store
(a) 64 frequency controlled mercury delay lines. Each delay line can store 32 short words of 5 decimal digits (actually 262 - 143). This gives QAS of 2 048 words consisting of 10 240 decimal digits. A short word consists of 18 binary digits and a sign digit; a long word, of 38 binary digits and a sign digit. Capacity of QAS is such that it can hold program as well as providing sufficient working locations for all current applications. Average access time to the store is 160 microseconds.

(b) 14 immediate access registers, each of 38 digits.

6 - Banking Store (Magnetic Drum)
(a) Auxiliary store for information composed of data or orders or both. Total backing store capacity can be up to 65 536 words, held on up to 8 drums.

(b) Each transfer of information from drums to main store is automatically checked to ensure that no corruption or misreading has occurred. Drum rotates at 5 470 revolutions per minute giving average access time of 5.48 milliseconds which need not add to the time of a job since transfers to and from the drum are carried out concurrently with other computer operations.

7 - Instructions
(a) The form of instruction is a single word of 19 binary digits, which are allotted as follows -

19-14	13-9	8-4	3	2-1
TUBE (delay line)	COMPARTMENT	BASIC ACTION	DIS	MOD NO.
ADDRESS		ACTION		

(b) There are 32 basic action numbers, divided into two groups according to whether they are modifiable. Odd action orders are modifiable; even action orders are not, in which case the modification number specifies variations to the basic action. Modifiable action enables sequences of operations to be performed on a series of different data, counting the number of different operations automatically. There are three modification registers.

8 - Basic Speed
(a) Pulse rate for computer - 525 kilocycles. Pulse rate for store - 2.1 megacycles/second.

(b) Minor cycle = long word time = 80 microseconds computer time.

(c) Major cycle = 4 long word times = .32 milliseconds.

9 - Average Speed
(a) Approximately 1500 average orders per second. An order to carry out addition or subtraction of numbers held in an arithmetic register takes .34 milliseconds.

(b) The time for multiplication varies according to the number of digits involved from .65 to 3.5 milliseconds. Division takes 3.5 milliseconds.

10 - Code
(a) Binary, serial. Word length - 19 or 39 binary digits.

(b) Single address code, orders stacked sequentially.

11 - Functions
Add, subtract, multiply, divide, square root, shift, collate, and auto-convert (binary-decimal/decimal-binary and binary-sterling/sterling-binary).

12 - Production
New factory at North Acton now in production.

13 - Delivery
About 18 months for standard computer.

14 - Monitoring Facilities
Permit immediate viewing of any of the contents of the stores or arithmetic units without stopping or in any way interfering with operation of the calculator.

15 - Price
Basic computer with three input and two output channels - approximately £68000 (excluding card and tape readers coupled to input channels, and card punch and line-a-time printer coupled to output channels). Quotations can be made for variation in the size of the quick access store and input and output mechanisms to suit the needs of a particular purchaser.

16 - Weight
197 hundredweight (excluding input/output equipment).

17 - Power Consumption
40 kilowatts.

18 - Floor Area
1250 square feet.

(16)

PCC (PROGRAMME CONTROLLED COMPUTER) - (Powers-Samas Accounting Machines (Sales) Limited)

1 - General Description
Small, general purpose digital computer.

2 - Uses
Primarily commercial, but can also be used for some scientific computing.

3 - Construction
One cabinet 12 ft x 2 ft 6 inches and separate power unit.

4 - Storage Capacity
Magnetic Drum - Input Store 40 words, Output Store 40 words, and Main Store 160 words. Six Immediate Access Stores.

5 - Access Times
(a) Magnetic Drum - 19.5 millisecs. (max.)

(b) Instructions - immediately available as all instructions are sensed continuously.

6 - Input-Output
(a) Powers-Samas Punched Cards 65 or 80 columns (with interstage gives 130 or 160 columns) alphabetical or numerical information.

(b) The input checked by second independent reading of input data. The output checked by independant sensing of punched results.

7 - Speeds
Feeds, processes and punches up to 7200 cards per hour. 120 cards a minute single stage working. 60 cards a minute normal and interstage working.

8 - Code
(a) Decimal or sterling. Word length 16 decimal or sterling digits plus sign and imparity check digits.

(b) Program held on pre-set program units, interchangeable for different routines.

(c) Each unit has 40 instructions and up to 4 units can be used simultaneously, giving 160 basic program steps.

(d) 80 instructions of built-in sub-routines including multiplication, division and number conversion.

9 - Production
Currently 50 a year; expected to reach 100 a year in two years. First deliveries have been made.

10 - Price
About £19,500.

11 - Delivery
2½ years.

12 - Air Conditioning
Not required for temperate climates (air cooling built into machine).

13 - Maintenance Staff
Provided by manufacturer.

14 - Cost of Maintenance
Included in the standard service charges.

(17)

UNIVAC I - (Remington Rand Limited)

1 - General Description
Large scale, general purpose magnetic-tape operated, high speed digital computer.

2 - Uses
Large scale commercial work; also used for scientific and technical computations.

3 - Construction
(a) Unit construction.

(b) Operates in binary-coded decimal, seven binary digits per character (termed Binary Excess Three). No need for programmed conversion on input or output of decimal data. Sterling amounts have to be converted to decimal pence (not binary pence as in straight binary machines).

(c) Every arithmetic operation is duplicated simultaneously by two independent units and results compared for agreement. Approximately 30% of hardware used for duplication and checking.

4 - Input-Output
(a) Input is by metal magnetic tape (prepared from Unityper, or punched card to magnetic tape converter, or punched paper tape to magnetic tape converter). Tape is ½" in width and up to 1500 feet long. Density from Unityper is 50 characters per inch and from converters or computer is 128 characters per inch. Tape moves at 100 inches a second, so reading/writing speeds can be up to 12000 characters a second.

(b) Speed of punched card converter is 240 80-or 90-column cards per minute. Speed of paper tape converter (5, 6 or 7 hole tape) is 200 characters a second.

(c) Output is on magnetic tape (then fed to high speed printer operating at 600 lines a minute, or to electric typewriter operating at approximately 10 characters a second, or to converters to punched cards at 120 cards a minute, or to paper tape at 60 characters a second).

(d) Two 60 word buffer-stores; data read from or written on magnetic tape in blocks of 60 words. Reading or writing of 60 words takes approximately 85 milliseconds (at recording density of 128 characters per inch). Computation may proceed during read and write operations. Tapes can be read backwards or forwards.

(e) Maximum of ten magnetic tape units can be used in installation.

5 - Quick Access Stores
(a) All QAS are temperature controlled mercury delay lines. 12 character words, one character of which is sign. Each word consists of 84 binary digits.

Stores			Capacity
100 of 10 words	=	1000 words	general storage
1 of 10 "	=	10 "	Arithmetic function
1 of 2 "	=	2 "	Storage.
4 of 1 "	=	4 "	
Total		1016	

(b) Word Time 40 microseconds; average access time to any word in 10-word Delay Lines is 200 microseconds.

(c) No drum backing-store, but speed of magnetic tape make it possible to use this as a backing store.

6 - Method of Using Store

Take information from magnetic tape to main store delay lines via buffer-store, process it by obeying instructions sequentially from main store, pass results to tape via buffer-stores. No need for optimum coding.

7 - Instructions

One-address code. One word contains two instructions of general form -

Function	Address of word to be operated on
3 Characters	3 Characters

8 - Functions and Speeds

(a) Wide variety of instructions, as follows -

	Average time
Add, subtract, test	0.53 Millisecond
Comparison	0.49 "
Transfer, extract	0.45 "
Multiplication	2.15 "
Division	3.89 "
Shift 0.25 millisecond &	0.04 " per digit

(b) Average of 2000 internal instructions per second. Basic pulse rate 2 megacycles (i.e. binary digit generated every half microsecond).

(c) 3 stages of operation -

(i) obtain address of next instruction,
(ii) obtain correct word from memory,
(iii) carry out instructions.

9 - Production

35 installed; no more will be produced once production switched to Univac II. Manufactured at present in U.S.A.

10 - Price

No longer quoted.

(18)

UNIVAC II - (Remington Rand Limited)

1 - General Description

Large scale, high speed, general purpose magnetic tape operated digital electronic computer.

2 - Uses

Large scale commercial data-processing; also used for scientific and technical computations.

3 - Construction

(a) Unit construction.

(b) All arithmetic units are duplicated.

4 - Storage Capacity

Magnetic cores - 2000 to 10000 words of alpha-numerical characters.

5 - Access Times

Magnetic cores - 40 microseconds.

6 - Input-Output

As for UNIVAC I, but tape density increased to 200 characters per second.

7 - Speeds

Input and output - 100 inches of tape per second.
Addition time - 191 microseconds ⁂
Multiplication - 333 microseconds ⁂
Division - 800 microseconds ⁂
Comparison - 191 microseconds ⁂
Transfer/Extract - 120 microseconds
Shift - 40 microseconds plus 40 microseconds per digit shifted.
(⁂ for 12-digit numbers)

8 - Code

As for UNIVAC I, plus -

(a) Field Selector, all instructions referring to memory operating under control of extract pattern.

(b) One-to-nine word transfer order, plus ten-to-sixty word transfer order.

9 - Production
Manufactured only in U.S.A., flow-line basis.

10 - Price
$825,000 basic: $1,240,000 average for complete installation in U.S.A.

11 - Delivery
18 - 24 months.

(19)

UNIVAC 120 - (Remington Rand Limited)

1 - General Description
Medium size, general purpose punched card input/output digital computer.

2 - Uses
Commercial, engineering and scientific.

3 - Storage Capacity
Input storage - 120 digits, Constant storage - 108 digits, Intermediate storage - 120 digits, Output buffer storage - 90 digits

4 - Input-Output
90-column punched cards

5 - Speeds
Input and output - 150 cards per minute, Addition time - 10 milliseconds, Multiplication and division - 50 milliseconds.

6 - Code
Programming by wired panel; punched card programme may be used for scientific and technical problems.

7 - Production
235 Installations (October 1955), including 4 in Europe.

8 - Price
$300000.

(20)

UNIVAC FILE COMPUTER - (Remington Rand Limited)

1 - General Description
Medium size, high speed, random access (drum), data-processing digital computer.

2 - Uses
Commercial data-processing, inventory, production control, etc.

3 - Construction
Unit construction, comprising a computer centre, to which different numbers of varying types of input and output may be added.

4 - Storage Capacity
Magnetic drums- up to 180,000 alphanumerical characters per drum and up to 33 drums.

5 - Access Times
Random access - 17.5 milliseconds average.

6 - Input-Output
Up to 24 input and output units can be connected, all or any being Adding machines, Book-keeping machines, Punched tape units, Electric typewriters, Punched cards readers and printers, or Magnetic tape units.

7 - Speeds
(a) Addition - 2 milliseconds.

(b) Multiplication - 26 milliseconds. Division - 33 milliseconds.

(c) Comparison - 0.5 milliseconds.

8 - Code
(a) Binary, serial.

(b) Externally wired plug-board (48 instructions) or magnetic drum stored program (1000 instructions) or combination of both.

(c) Word length can be varied from machine to machine, but remains constant when decided upon. 2-address code.

(d) Four magnetic tape units can be assigned to the system's automatic sorter which can operate without tying up the central computer. Speed is about 10,000 120-character items per hour.

(e) File Computer can be programmed to interrupt a job to deal with queries from other input units (such as key-board or punched cards), answering these and then returning to original job.

9 - Production
10 installed; 120 on order. Manufactured only in U.S.A.

10 - Price
$105,000 basic: $200,000 average for complete installation in U.S.A.

11 - Delivery
18 months.

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10 - INPUT/OUTPUT METHODS, MECHANISMS AND MEDIA

This report is based on the preliminary studies of three groups of members. The subject covers many of the most important practical problems of computer work in the business sphere, but the report is not claimed to be complete or beyond question. It is suggested that a detailed study by specialists, with a view to the preparation and publication of summaries or digests of basic information, would be of value to potential users of computers in the business sphere.

1 This preliminary survey was not related to any specific application or to a particular type or make of computer but was limited to the following general aspects -

(a) Existing methods and devices for -
(i) input of new data (i.e. anything prepared externally to the computer for a particular operation) and
(ii) output of information from the computer in readable and/or storable form.

(b) Current developments and improvements in input and output devices and media.

(c) Methods of preparing information for presentation to the input device; considering also the means whereby the commencement of data processing could be moved further back from the computer nearer to the point of origin of the information.

(d) General business requirements for the development of special equipment.

2 The application of computers to commercial and industrial work necessitates a very careful study of the methods of feeding data into, and obtaining the results from, the computer; it is probably true to say that the choice of input-output media has an important bearing on whether a job can be done on a computer and, if so, what type and make of machine would be most suitable and economic.

3 To this end an attempt was made to set down in simple non-technical language and in logical sequence a brief description of the main types of input-output media at present available, their basic characteristics, the means whereby they are fed into the computer, etc. The results are set out in three appendices, each covering one type of input/output media -

Appendix A: Magnetic Tape and Film
Appendix B: Punched Cards
Appendix C: Punched Paper Tape

The relative merits of these media are summarised in a Table of Relative Characteristics (Figure 1).

4 It is emphasised that the weighting to be given to the characteristics in the table will vary according to the nature of the work which may be the subject of investigation. Taken in conjunction with a knowledge of the circumstances surrounding the work (e.g., the volume of original data, whether it arises locally, how it can best be transmitted to a central point, whether local access to computer results is required, whether long-term storage of information is necessary), the comparisons set out in the table could assist in indicating what might be the best initial lines of investigation.

5 Generally it is considered highly desirable that the design of computers should incorporate facilities which will permit all three types of input/output media to be employed as required for particular jobs.

6 In considering the problem of preparation of input, the cost of creation must be considered as well as the speed of preparation.

7 The approach to all data creation problems should be to eliminate punching and verifying cards or tape as far as possible.

8 In many applications, special equipment could be developed to make data automatically available in a form suitable for computer input. A good example of such equipment would be payroll work where an automatic record of clockings-on and clockings-off could be produced.

9 To facilitate the preparation of sum checks of initial data for subsequent use in checking computer operations, it would be useful to have the tape or card verifier fitted with an adding register to provide an automatic total of digits or characters punched.

10 In all known character recognition developments, the problem of document feeding at a suitable rate has proved a serious one.

11 Certain documents, such as suppliers' invoices, might never be sufficiently standardised to permit the use of character reading techniques.

12 Full comment on this subject is premature but future developments in the field should certainly be of considerable interest and use to commercial firms.

13 United Kingdom firms seem to be lagging in the development of magnetic ink recording methods.

14 In the field of output mechanisms, very high speed devices are being developed. These devices may well give rise to a demand for an unnecessarily large volume of output. Requirements of output should be very carefully considered in all applications.

15 Xerographic printing methods should become available in the next few years, and developments in this field should be of considerable interest.

16 When continuous stationery is being used, it should be borne in mind that it is easier to feed continuous stationery into a line printer than into an electric typewriter.

APPENDIX A

MAGNETIC TAPE AND FILM

Note - Magnetic film in this context must not be confused with the ultra-thin evaporated films of magnetic material now being experimented with in the U.S.A. for high speed internal storage - Ed.

PHYSICAL CHARACTERISTICS

1 Magnetic tape is a ribbon of plastic or metal, physically similar to that used on sound recording systems. Magnetic film has the same base as ordinary cinematograph film.

2 The surface is coated with a compound, tiny spots of which are capable of being made into entirely self-contained magnets.

3 Magnetic tape or film may be likened to cinematograph film which records, instead of pictures, elementary magnets of N/S or S/N polarity.

FIGURE 1

TABLE OF RELATIVE CHARACTERISTICS

	Characteristics	Punched Cards	Paper Tape	Magnetic Tape or Film
1	Ease of reference and identification	+	o	-
2	Ease of verification	+	+	-
3	Flexibility (i.e., availability for purposes other than computer input)	+	+	o
4	Takes Alpha and Numeric characters	+	+	+
5	Can carry own visual interpretation	+	o	-
6	Sorting: (a) mechanical (b) with computer	+ Not practicable	- Not practicable	- +
7	Data can be obtained as a by-product of other accounting processes	+	+	-
8	Convertible to the other media	o	o	o
9	A known and tested medium	+	+	-
10	No limit to amount of data held in a block	-	+	+
11	Small physical size in relation to capacity	-	o	+
12	Transportability	-	+	+
13	High reading speeds	o	-	+
14	Re-use of the medium with new data	-	-	+
15	Manual punching speeds	o	o	o
16	Freedom from effect of dust	+	+	(See note 1)
17	Freedom from effect of atmospheric conditions	o	+	(See note 1)
18	Acceptance for tax and audit purposes (See note 2)	+	-	-
19	Cost per digit (See note 3)	-	+	-
20	Ease of loading medium onto apparatus (See note 2)	+	o	-

KEY: + = high merit o = medium merit - = low or nil merit

Notes: 1. Applies to plastic tape with heads in contact. Magnetic film with heads out of contact is reported to be considerably better.

2. These items appear to have aroused some controversy - Ed.

3. Cost of medium only, not equipment.

Plastic Base

4 All makes of tape but one are plastic, and are usually acetate based. An improved plastic known as 'MYLAR' is now coming into use.

5 The disadvantage of plastic tape (based on American experience) is that it can stretch and distort, especially under humid conditions.

6 Plastic tape varies from $\frac{1}{2}$ inch to 3 inch in width, is usually wound on reels 8 inches to $10\frac{1}{2}$ inches in diameter, containing from 2 400 to 3 600 feet, but lengths as short as 50 feet may be used. Reels weigh from 10-12 ounces and the tape weighs one ounce per 100 ft.

Metal Base

7 Metal tape (phosphor bronze) is supplied, it is believed, by only one organisation (Remington-Rand).

8 Its advantages compared with plastic are claimed to be its freedom from flaws, that it is more fireproof (although fire would undoubtedly destroy the magnetism of the record) and generally more robust.

9 Its disadvantages are that it is heavy and bulky. It tends to act like a coiled spring when on the reel and to unwind.

10 Metal tape is $\frac{1}{2}$ inch in width and is normally wound on reels containing 1 500 feet, weighing 5 lbs.

Iron Oxide Coating

11 The iron oxide (or other compound) is usually applied as a surface coating, but in one instance has been 'sandwiched' between two layers of MYLAR.

12 Ideally a tape with no imperfections in its magnetic coating is required. In practice I.B.M. is the only computer manufacturer who insists on using perfect tape; the cost is between two and three times the cost of tape with some flaws.

13 The usual practice is to accept a tape that has a certain amount of flaws and to mark these areas off so that no reading or writing takes place there. This is quite satisfactory in practice.

Nickel Cobalt Coating

14 This alloy is coated on metal tape only.

Magnetic Film

15 One firm in Great Britain (National-Elliott) is using photographic film as a base.

16 The writing and reading heads are not in contact with the film as is usual with plastic tape. Advantages claimed are that the magnetic spots are larger than on magnetic tape, that they are not packed so densely, and that consequently any possible liability to reading or writing errors is reduced.

17 A possible disadvantage of magnetic film is that it has a slower input/output speed than tape.

18 Magnetic film is 35 mm. wide, is sprocket fed, and is wound on reels containing 1 000 feet.

GENERAL CHARACTERISTICS

19 Information is recorded by magnetising spots on the coating on the tape or film, each spot representing a digit in the binary code. A magnetic spot on the surface of the medium represents 0 or 1 in the binary notation.

20 This means that the information is not in a visible form, as with punched cards or paper tape.

21 At present magnetic tape or film must be prepared by conversion from other data sources (punched cards, paper tape or computer). It cannot be prepared as a by-product of accounting or typing processes, and as far as is known there is at present only one machine, the Remington Rand 'Unityper', on which direct recording can be made.

Writing

22 Magnetic tape or film is passed under a 'writing head' similar to those used in ordinary commercial tape recorders, which creates spots of magnetism on the medium according to a pre-determined pattern. The recording is for practical purposes permanent, and the magnetic spots can only be removed by positive action by the computer or operator.

Reading

23 The 'magnetic writing' can be 'read' by passing the tape or film under a 'reading head' which senses the spots and interprets the pattern into electrical impulses. Often the same head is used for both reading and writing.

24 Usually reading must be done while the tape is travelling in the same direction as when the information was recorded, but there are exceptions.

Input and Output

25 Magnetic tape or film is suitable for input and output. It is a robust material which permits fast mechanical handling in the input and output units.

External Storage

26 Magnetic tape or film is a flexible means of external storage. It is non-volatile (i.e. it does not depend on a continuously maintained current to preserve the information).

27 When used for external storage, up-dating is usually effected by preparing a new tape or film, not by erasing or writing over.

Hazards

28 The chief hazard in the use of magnetic tape in this country is likely to be dust, which causes loss of digits ('drop-outs'), and steps have to be taken either to keep the tape and the writing and reading heads free from dust or to correct errors due to drop-outs. This hazard is claimed to be negligible with magnetic film.

After Use

29 Information is automatically erased as new information is written, and magnetic tape or film may be used for repeated processing, thus reducing recording costs.

PACKING OF DIGITS

Density

30 The magnetic spots can be packed at a high density of from 100 to 200 to the inch, and developments are in hand for even closer packing.

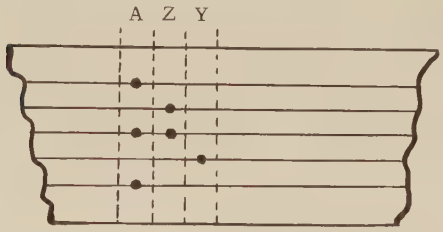
Tracks

31 It is usual to have several tracks running the length of the tape or film, each with its own reading and writing head. The heads are mounted together in one assembly.

32 Usually one track is used as a 'clock' track, carrying a regular series of spots, analogous to the sprocket holes in punched tape, defining the location of spots on the other tracks. Another track may be used for a parity check (see paragraph 75 below); the rest are called 'information tracks'.

33 There are two methods of storing the 'bits' (i.e., the magnetic spots or binary digits).

34 The first method, parallel storage, is more usual in commercial application. In this method, all the 'bits' (i.e., magnetic spots or binary digits) on the several tracks at a certain point on the tape are regarded as contributing to a single piece of information, usually a character, as illustrated below.



35 The second method is to regard each information track as self-contained, in which case the information is stored in 'bits' serially along each information track.

ARRANGEMENT OF DATA

36 Data is arranged along a tape or film systematically, that is, the spots are packed on the surface according to a pattern. The pattern varies according to the make of equipment and the requirements of the work.

37 Usually the data is divided into blocks, which may be either all of the same fixed length or of variable lengths. Information is written and read in complete blocks.

38 The beginning of each block is indicated by a special symbol called a 'block marker' which may or may not be recorded on a separate track. An address may also be recorded with each block, possibly on a separate track; in the latter case it may serve as the block marker.

39 Reflective or transparent spots on the tape or film can be sensed photo-electrically and are often used to indicate the physical end of the tape or the beginning of a section of recording.

Fixed Length Blocks

40 Each block contains the same number of words. Block markers and addresses are often put on when the tape or film is prepared prior to use.

Variable Length Blocks

41 The blocks vary in size and the end of each block is signified by a special symbol.

42 Blocks can be any length up to a certain maximum, and may thus contain one or several hundred characters. Variable block lengths simplify the recording of complete historical data about a person or product in one record.

Inter-record Gaps

43 Gaps between blocks of information are usually left so that the reading unit can -

(a) sense the end of a block,
(b) stop,
(c) start up, and
(d) reach full speed before the next block of information is reached.

44 Alternatively the unit can stop and 'back-space' to the end of the block which has been read and start to read again from that point. With this method no gaps are required but the control is more complicated.

45 Another method is to prepare and use the tape or film so that the gaps left in its forward running direction contain information which is read when it is run in reverse.

Magnetic Film

46 Magnetic film as used by National-Elliott is divided into two halves along its length, one of which may be read from or written on when the film is moving in each direction.

47 With the last two arrangements described, it is usual to use the backward-recorded part of the tape or film as a continuation of the forward-recorded part. Thus when the whole tape or film has been recorded or read it is in its initial position and no rewinding is required.

AVAILABILITY OF TAPE

British Tape

48 Although tape is manufactured by several firms for commercial tape recorders, there is at present no tape being produced in Great Britain which has satisfied in use the high standard required for computers.

49 The difficulties experienced arise from the problems of obtaining a sufficiently fine coating to avoid losing or picking up digits in operation.

50 Development is going on and likely suppliers at some future date are -

(a) Electrical and Musical Industries Ltd. (EMI),
(b) Master Sound Systems Ltd. (MSS) and
(c) Minnesota Mining and Manufacturing Co, Ltd. (MMM).

American Tape

51 Most tapes used with American Computers are supplied by Minnesota Mining and Manufacturing Corporation.

52 The quality of tapes is very high whether of the 'perfect' or untested type.

TAPE SPEEDS

53 Tape or film does not feed continuously; it frequently stops and starts between the reading or writing of blocks of information.

54 The information is 'read' into the computer proper via a buffer store usually holding the contents of one block; as soon as the buffer is full the tape feed stops automatically.

55 This stopping process takes an appreciable time (e.g., 10 milliseconds), as does the process of starting up again in order to 'read' the next block of information. The reels themselves take much longer to start and stop; hence the need for long loops of 'slack' tape between the reels and the reading and writing heads.

Write/Read Speeds

56 Tape usually moves at from 60 to 100 inches per second. There is a promise of achieving several times this rate in the not too distant future.

57 These speeds represent rates of 6 000 to 40 000 characters per second.

58 Operating speeds are less than the above reading and writing rates, as allowance must be made for acceleration, deceleration and stopping.

Comparative Speeds

59 In practice, many factors enter into the question of relative speeds. The following figures afford a rough comparison of the maximum 'reading' rates of various media, and are intended simply to emphasise the very high speed of magnetic tape. Actual speed is dependent on the nature of the work; the higher speeds are not necessarily required for commerce.

	Characters per second
80-column Punched cards (Standard Equipment)	266
80-column Punched cards (Elliott High Speed Reader)	667
Punched Paper tape (Standard Equipment)	200
Punched paper tape (Ferranti Experimental)	1 200
Magnetic tape	5 000 - 30 000

Rewinding

60 After a tape has been 'written' on or 'read' it is usually necessary to wind it back so that the information is in correct sequence for further use.

61 Rewinding speeds vary from 80 to 500 inches per second, equivalent to about 1.2 to 6.2 minutes per $10\frac{1}{2}$ inch reel, allowing for acceleration and deceleration time.

Back Spacing

62 Back spacing is effected at the same speeds as 'writing' and 'reading'.

Changing reels

63 Changing tape reels is not an easy operation to the unskilled; the time required varies from 15 seconds to 3 minutes depending on the make of equipment and the skill of the operator.

ACCESS TO INFORMATION

64 When magnetic tape is used for external storage, it is highly preferable to set out information in the required sequence to facilitate access by the computer. Random access could be a comparatively expensive use of the computer.

65 There are, however, some circumstances which justify the use of tape essentially as a supplement to the internal store, and some equipments allow the tape to be positioned automatically at any desired block when instructed by the computer.

Printing Out

66 Some magnetic tape printers allow blocks containing distinguishing symbols to be ignored or printed in a special manner.

EQUIPMENT

67 When magnetic tape is used on a computer, the computer must be provided with equipment which can 'write on' or 'read' the tape; this is commonly called a 'tape deck', and consists of two main parts -

(a) that concerned with 'reading' from or 'writing' on the ape by electro-magnetic means; and
(b) that concerned with driving and stopping the tape.

68 The essential components in the reading and writing processes are the heads, which have already been described in paragraphs 22 and 23.

Drive Mechanisms

69 In the commercial tape-recorder it is easy to drive the tape and to stop it at any required point because the speed is low. In tape decks used with computers, however, the tape has to be driven at a much higher speed. Nevertheless it must be capable of stopping in, for example, 10 milliseconds and of attaining full speed again in the same time. Difficulties have been experienced in developing tape decks which possess these abilities, and this is the main reason why there are as yet no British-made tape decks in use.

Direct Recording

70 At present only one firm has produced equipment which permits the direct recording of information on to magnetic tape. Remington Rand have in use a UNITYPER which produces typed copy with a 'translation' in a binary coded decimal convention on magnetic tape.

71 There is some difficulty in verifying and correcting tape produced by the Unityper. At present, either it has to be printed out and checked visually, or a second tape must be produced by repeat 'Unityping' and the two tapes compared in a computer run. A verifying machine - the UNIVERIFIER - has just been produced.

Card-to-tape and Tape-to-card Converters

72 To overcome the drawback that tape is not normally produced direct and cannot yet be prepared as a by-product of other accounting and typing processes, high speed machines have been developed by means of which magnetic tape can be prepared from punched cards and tape can be translated back into punched cards.

British Tape Decks

73 No British tape decks suitable for use with a computer are at present in commercial use. Several English firms have produced prototypes, and it is anticipated that production will begin in the next year or two.

American Tape Decks

74 The following firms are known to be using or making tape decks which have been proved in actual use -

(a) Datamatic Corporation;
(b) Electrodata Corporation (Datatron);
(c) International Business Machines (IMB700 series magnetic tape units);
(d) Potter Instrument Co. Inc. (British Agents:- International Engineering Concessionaires Ltd.);
(e) Radio Corporation of America (Bizmac); and
(f) Remington-Rand (Uniservos).

Others about whose products little is known are -

(g) Addressograph - Multigraph Corporation;
(h) Ampex Corporation; and
(i) Anelex Corporation (Micro-Tapestepper).

(A table of comparative data of some American magnetic tape equipment is given in Figure 2. Full details of the tape-decks produced by the above firms are given in the publication 'Office Automation', published with an updating service by Automation Consultants Inc., 1450 Broadway, New York 18, N.Y.)

CHECKING DEVICES

75 In 'reading' the most likely error is to miss a single 'spot'. To overcome this there must be an automatic check that 'spots' have been 'read'. The most common form of check is known as a 'parity check'.

76 A parity check is applied to a group of binary digits (each represented by a spot on the tape). When recording, the number of digits having the value 1 is automatically counted and an extra digit is added whose value depends on whether the number of 1's counted was even or odd. When reading, the 1's are again counted and the extra digit is checked for agreement. Some parity checks count across the tape, others along the length of the tape. IBM uses both types together.

77 Alternatively to a parity check along the tape, a sum check may be applied by adding the numerical values of all the characters in a block and recording the sum at the end of the block. This is less liable to compensating errors than a parity check.

Corrective Action

78 With some equipment, an error detected in 'reading' a tape will signal the need for a corrective measure by stopping the machine.

79 Alternatively, a unit can be designed or programmed to back-space the tape automatically and to 're-read' the record, with an excellent probability that the record will be read accurately the second time.

80 One British manufacturer has developed a system which permits a simple programmed correction procedure during writing also. The tape passes from the writing head to a second head where it is immediately read and a sum check is automatically applied.

APPENDIX B

PUNCHED CARDS

1 Punched cards havebeen in use for a considerable number of years as input/output media for a wide variety of non-electronic data-processing equipment. With the development of electronic computers punched cards formed a natural, ready-to-hand and tested form of input/output. The cards used for this purpose are the normal types used in conventional punched card equipment.

2 The following description of punched cards, equipment and procedures are related to their use for electronic computers, and do not purport to give a full description of all punched card equipment and techniques.

PHYSICAL CHARACTERISTICS

3 Cards are made from stout manilla paper of sufficient strength to withstand the wear and tear of passing many times through machines at high speed.

4 Sizes of cards vary from 2ins. x 2 3/4ins. to 3 1/4ins. x 7 3/8ins.; the average thickness is about 150 cards to the inch and they are generally stored in trays holding about 2 000 cards.

GENERAL CHARACTERISTICS

5 Information is recorded by holes punched in the card, the significance of a hole depending upon its position relative to the edges of the card.

6 The card is divided into a number of vertical columns. The number of columns employed by the systems in use in the U.K. are 21, 36, 40, 65, 80, 130*, 160* (Powers Samas); 38, 80 (Hollerith); and 80 (I.B.M.).
(*In these cases the columns are overlaid in pairs with punching positions interlaced.)

7 Each column is divided into twelve positions and of these ten are used for recording the digits 0-9. The remaining two positions are used variously for recording 10 or 11, the month of the year, or, in conjunction with one other hole in the same column, as a code to represent an alphabetic character. At present there is no standard coding for computer use.

8 For any given job adjacent columns are grouped to form 'fields', each sufficient to permit the recording of the highest number required for that particular piece of information. Thus a number of four digits would require four holes to be punched, one in the appropriate position in each of four adjacent columns.

FIGURE 2

TABLE OF COMPARATIVE DATA OF SOME AMERICAN MAGNETIC TAPE EQUIPMENT

System	Base material	Coating	Width of Tape (ins.)	No. of Tracks	Length of reel of tape (feet)	Cost of reel of Tape (dollars)	Packing Density (Characters per inch)	Tape Speed (ins. per sec.)	Start/Stop Time (Milliseconds)	Read/Write Rate (Characters per sec.)	Rewind Speed (ins. per sec.)	Capacity of Reel of Tape (Million bits)	Capacity of Reel of Tape (Million characters)
Electrodata Corporation (Datatron)	Plastic (Acetate based)	Iron Oxide	¾	12	2 500	36	100	60	6	6 000	120	24	4
Datamatic Corporation	Plastic (Mylar "Sandwich")	Iron Oxide	3	31	2 700	775	800	100	-	40 000	-	150	24.8
Stanford Research Institute (ERMA)	Plastic (Mylar)	Iron Oxide	¾	9	2 400		133	75	-	9 975	-	23	3.8
International Business Machines	Plastic (Mylar)	Iron Oxide	½	7	2 400	69	200	75	10	15 000	500	30 to 40	5 approx.
Radio Corporation of America (BIZMAC)	Plastic (Acetate based)	Iron Oxide	⅝	14	2 400		125	80	-	10 000	80	12	2
Remington Rand (UNIVAC I)	Phosphor Bronze	Nickel Cobalt	½	7	1 500	60	128	100	22	12 800	100	10	1.4
Remington Rand (UNIVAC II)	Phosphor Bronze	Nickel Cobalt	½	7	1 500		200	100	7.5	20 000		20	2.8

NOTES -

1. Electrodata Datatron - Each block of information has its own address
2. Datamatic - Characters are recorded in serial form along each track. Alternate blocks of information are read in each direction.
3. ERMA - Given capacity of reel of tape assumes no gaps. In practice a considerable portion of the tape would be left blank.
4. R.C.A. Bizmac - Each character is recorded and read twice.
5. Remington-Rand Univac - "Mylar" plastic tapes are under development.

Special codes are employed, in some circumstances, to enable the capacity of the columns and of the card to be increased beyond the normal.

EQUIPMENT FOR THE PREPARATION OF CARDS

Hand Punches

9 On the simplest punches the manual depression of a key causes the perforation of one hole in the card. One key is provided for each of the twelve punching positions, with additional keys for column spacing and skipping and for releasing the card. It is unusual for anything but straightforward punching to be done on these machines.

Automatic Punches

10 Punches under this heading, where cards are fed into and ejected from the machine automatically, can be split into two groups -

(a) Machines where the depression of a key causes electrical operation of the corresponding punching knife and where common information can be punched into the cards by the plugging of a control panel or some similar device.

(b) Machines where a key depression causes the required digit to be entered into some form of store. Information is punched into the card only at the completion of recording for that card, or at intervals during the recording. On such a machine it is possible to 'erase' one or more columns which have been stored if the operator realises that an error has been made. Common information can be punched into the cards as under (a) above.

Machines of both types can be obtained with additional facilities for 'gang-punching', which consists of repeatedly copying columns back from the preceding card. This operation can be interrupted at any time by the operator in order to enter new 'master' information in the card then being punched. This information will then in turn be copied into successive cards as they are punched.

11 It is possible to obtain a typewriter keyboard with most automatic punches to facilitate the punching of alphabetic characters.

Verification of Punched Information

12 The two systems in general use are -

(a) By comparison: the cards are fed into a verifier (which is externally similar to the punches described above) and the keys depressed by the verifying operator should match the holes already punched in the cards. In case of disagreement the machine locks automatically, and the operator takes correcting action according to whether the card is incorrectly punched or the wrong verifier key was depressed.

(b) By off-set punching and automatic verification: using the punch the original punching in the cards is reproduced in a slightly off-set position, thus forming an elongated hole wherever the two punchings agree. The cards are then fed through an Automatic Verifier, which checks that every hole is elongated and indicates cards which do not pass this test.

Dual Purpose Cards

13 All the above-mentioned punching is done from information on an original document or from information written on to part of the card itself. In the latter case the card, known as a Dual-Purpose card, contains information in both written and punched form; this has many practical advantages and uses.

Mark Sensing or Scanning

14 Under this system the data to be recorded is first denoted by pencil marks in printed 'boxes' on the card itself. Cards thus marked are passed through a machine (either a special purpose machine or a suitably fitted reproducer), and the pencilled information is sensed and converted into punched holes.

Reproduction of Punched Information

15 Using a Reproducing Punch, information punched into cards can be copied into other cards. All or any selected columns can be reproduced and the machine can also be used for gang-punching common information into a pack of cards.

Cards Produced from Tape Recordings

16 Card punches have been linked to paper tape readers so that cards may be punched from data recorded in the tape; machines also exist for carrying out the reverse operation.

17 Equipment is also available by means of which punched cards may be prepared from magnetic tape recordings and vice versa.

By-product Cards

18 Machines are in use in America, and are in the initial stages of development in this country, which enable punched cards to be prepared as a by-product of normal operations on accounting machines and typewriters, all or any selected information being punched into the cards.

INPUT AND OUTPUT

Input

19 Information in punched cards is fed into the computer in a similar manner to that employed for conventional punched card equipment. The cards can be read either 'serially' (column by column) or 'in parallel' (row by row). Readers also exist which read all positions in the card simultaneously. Serial readers are being developed for use with computers as they provide the data in a more convenient flow to machines which are themselves serial.

20 The actual method of reading can be under one of three general headings -

(a) Mechanical, where small pins, one for each reading position, 'sense' the face of the card. Where a hole is present the movement of the pin through the hole is transmitted mechanically via a Bowden cable to actuate some other appropriate mechanism, which may itself give rise to a mechanical movement or to the generation of electrical impulses. In this system the card is brought to rest before reading can take place.

(b) Electrical, where the card moves between a metallic roller which is a source of current and a set of wire brushes, one for each reading position. As the card is an insulator a brush will pick up an electrical signal only when it makes contact with the roller through a hole. This signal can then be used to transmit information into the computer.

(c) Photo-electrical, which is somewhat similar to (b) save that a source of light on one side of the card is cut off by the card from a row of photo-cells except where a hole exists. The effect of the beam of light striking the photo-cell is to generate a small electrical signal which can be amplified and used as required. The advantage of this latter technique is that the reading does not require any physical contact with the cards; this is an important consideration when feeding cards at high speeds.

Output

21 Resultant information produced by the computer is transmitted to punching equipment, which produces a punched card record, either detailed or summary according to predetermined requirements. Serial or parallel punching can be used.

SPEEDS

22 Card input speeds to the computer are normally at the rate of approximately 200 cards per minute (using 80-column cards). Some card readers being developed in this country give higher speeds (e.g. National-Elliot have in use a serial reader for which a speed of 500 cards per minute is claimed).

23 The punching out of cards from the computer is at present at the rate of 100-120 cards per minute.

ADVANTAGES AND DISADVANTAGES

24 Punched cards have certain advantages, listed below, over other types of input/output media for computers. The weighting to be given to these factors will depend upon the circumstances surrounding the work involved.

(a) The ability to sort mechanically (on a punched card sorter) large or small packs of cards; this may be more economical than using the computer to sort the data.

(b) The fact that the information recorded is in a visible form, and may also be printed or written on the cards.

(c) Ease of verification and correction of punched information.

(d) The ability to produce independent control totals on a tabulator.

(e) Random access to a very large file by hand picking.

25 Input/output speeds however are much slower than those of magnetic tape, although they compare favourably with paper tape in this respect. If the time taken by the computer to produce the resultant answer from the input data is less than the time taken to feed in the information, the slower speed of punched cards can mean that the most economical use is not being made of the computer, which is the most expensive element in electronic data processing equipment.

26 Punched cards also constitute a much more bulky form of storage of information than does magnetic tape, and this may be a practical disadvantage where a considerable amount of data has to be retained for long periods.

APPENDIX C

PUNCHED PAPER TAPE

PHYSICAL CHARACTERISTICS

1 The paper tape used as either input or output is identical to that which is used on normal telegraphic or teleprinter applications. Virtually any texture of paper can be used provided it is reasonably strong. Punched paper tape is available in a variety of widths, but the most common in this country is 11/16ins. wide. Tape is normally supplied in reels 340 yards long; it can be cut to length and joined (or spliced) as required.

GENERAL CHARACTERISTICS

Tape Punching

2 Punching can be carried out on an increasingly wide range of machines. In many of the machines available on the market, tape punches have been added to standard office machines such as typewriters, cash registers and accounting machines, and punched tape is produced automatically as a by-product of the normal operation of that machine. The punching code can represent numbers, alphabetical characters and a few other symbols.

Tape Reading

3 This is achieved by passing the tape under a reading head. The most common type used for computer input is photo-electric. In operation, the tape is passed under a light source and photo-electric cells register the holes in the paper tape as they pass. This enables the coded information contained in the tape to be converted to electrical impulses which are transmitted to the computer.

Input and Output

4 Punched paper tape is one of the most common forms of input and output used on digital computers. Speeds for both input and output are slow by comparison with magnetic tape, but punched paper tape has the advantage at this stage in the development of computers of being a tried and tested medium.

External Storage

5 Punched tape could be used as a method of external storage, although in practice this is not done on a large scale. Once the tape is punched there is no very satisfactory process for dealing with amendments, apart from the preparation of a new tape by reproduction and editing.

PACKING OF DIGITS

6 Punched tape can be used in 5, 6, 7 or 8-channel form (i.e., the coding can utilise a maximum of 5, 6, 7 or 8 rows of punched holes along the length of the tape). The 5-channel form is normally used in this country. Each additional channel doubles the number of codes which can be punched. In all cases the punching is equally spaced at intervals of 1/10ins. along the length of the tape (i.e., 10 digits or characters per inch of tape).

7 Data is punched in a coded form, the code for each symbol being constructed from a combination of holes punched in a row across the tape up to the maximum number for that particular size of tape (e.g. up to 5 in a 5-channel tape). There is also a continuous row of smaller holes ('sprocket holes') near the centre of the tape for the purpose of feeding it through the various pieces of equipment.

8 In a 5-channel tape there are 32 possible combinations of punched holes which, coupled with the use of a shift combination, covers the 26 letters of the alphabet, as well as the 10 decimal digits, punctuation marks, etc. Special signals, such as 'end of word', must also be covered by the code. When using punched tape for printed output, other special signals such as 'line feed' and 'carriage return' must also be included. Any requirements beyond this are best provided for by the use of 6, 7 or 8-channel tape. At present there is no standard coding for computer use.

SPEEDS

9 The speed of punched tape preparation is dependent on individual operators. When punched tape is prepared as a by-product of typing or accounting operations, the speed of tape preparation is dependent on the speeds of the primary operations.

10 The following figures give some idea of the speeds of computer input and output attainable with punched tape -

(a) Input reading -
  (i) Standard - 200 characters per second;
  (ii) Ferranti Experimental - 1 200 characters per second.

(b) Output (perforating) -
  (i) Standard - 33 characters per second;
  (ii) Several manufacturers have developed much faster perforators but these are not yet in general use.

EQUIPMENT

Preparation Equipment

11 The first equipment to be used consisted of Creed equipment in which tape is punched by the depression of keys on a special keyboard machine. Machines are also available for comparing and copying tapes with or without corrections.

12 Punched paper tape can now also be produced as a by-product of other operations. Some of the systems available are described in the following paragraphs (13 - 18).

Creed-Underwood: Typewriter Perforater

13 This machine, producing paper tape as a by-product of normal typing operations is fully developed but not at present in production owing to lack of demand.

Flexowriter

14 This American machine, manufactured by Commercial Controls Corporation, is sold in this country by Block and Anderson Limited. The machine produces tape as a by-product of normal typing operations. It will also reproduce tape with or without amendments, and will produce a typed copy from it. Several versions are available for 5, 6, 7 or 8-hole tape, with various editing facilities involving up to two tape readers and two perforators.

National Cash Register Co. Ltd.

15 A range of cash registers, accounting and adding machines produce punched paper tape records of all or selected transactions recorded on the machines.

Friden Calculating Machine Co. Ltd.

16 A range of calculating machines, marketed in this country by Bulmers (Calculators) Ltd., produce punched paper tape as a by-product of their normal operations.

Burroughs Sensimatic-to-Tape Machines

17 A range of accounting machines is equipped with a paper tape punch. Any items can be selected for punching as required.

IBM

18 IBM in this country has machines that produce paper tape as a by-product of a manual typing operation.

Reading Equipment

19 Ferranti Ltd. produce a punched tape reader for use with digital computers. This unit is the one in most general use with computers at present, being constructed in the U.K. and the U.S.A.

Printed Output

20 Punched paper tape produced as output from a digital computer can be used to operate character printers which translate the data so punched into printed copy. At present normal printing speed is 7 to 10 characters (or spaces) per second, but faster electric typewriters which double this speed are being tested. Machines in this line include -

(a) Compuprinter, marketed by Elliott Brothers (London) Ltd.,

(b) Creed Teleprinter Equipment, and

(c) Flexowriter, marketed by Block and Anderson Ltd.

CHECKING DEVICES

Verification of Tape

21 There are five approaches to this problem -

(a) Punched tape produced as a by-product can be verified by reading the typed copy on the machine.

(b) Using certain types of equipment manufactured by Creed and Company Ltd., a visual interpretation of the punched information can be printed along the edge of the tape.

(c) Punched tape produced as a by-product of an adding or accounting operation might be susceptible to a sum check using totals produced independently of the punching run.

(d) 5-channel tape can be checked and corrected by passing it through an equipment known as a Verifier manufactured by Creed and Company Ltd. The operator depresses the Verifier keys as though punching from the original document. So long as the key depressions agree with the punching of the original tape, this punching is copied into a second tape. Any discrepancy causes the keyboard to lock and the operator can then examine the situation and ensure that the correct symbol is punched into the second tape.

(e) Creed and Company also produce a Comparator for 5-channel tape. This enables two tapes prepared independently to be compared for agreement. One version of this equipment simultaneously punches a third tape. When the first two tapes disagree the machine stops and the operator can ensure that the correct symbol is punched in the third tape.

Parity Checks

22 A system of parity digits is possible on punched tape as on magnetic tape (see Appendix A, paragraph 76). The check is always applied to individual symbols (i.e. to rows of holes across the tape). In the case of 5-channel tape it is not possible to have more than 16 different symbols when one channel is being used for a parity digit; this however is sufficient to permit the checking of purely numerical information.

B.C.S. NOTES

REGIONAL BRANCH ACTIVITIES

Branches of the Society have now been formed in Manchester and Birmingham, and are in course of formation at Cardiff, Glasgow, Leeds, Newcastle and Nottingham.

Until these branches have held their inaugural meetings and elected their officers and committees, members within reach of these centres should contact the Society's London office for details not available at the time of going to press. Programmes of activities will be published in future issues of THE COMPUTER BULLETIN.

The committee of the branch in MANCHESTER will be elected at the first public meeting, to be held at the Manchester College of Science and Technology, Sackville Street, Manchester 1, on the 14th October at 7 p.m., when the speaker will be Dr. B.V.Bowden, M.A., Ph.D., M.I.E.E.

The BIRMINGHAM branch has arranged its first meeting for the 25th October.

STUDY GROUPS FOR THE NEW SESSION

The 1957/58 Study Group session of the Business Group will start in October 1957 and continue through the winter until March 1958. Each study group will be formed of about 25 members; if the support for any one group is considerably more than this number, additional groups will be formed in that subject.

The organisation of each group is left to the members to evolve, only the Chairman being appointed by the Committee. Each group is expected to prepare a report on the session's activities, and it is anticipated that these reports will be published at the end of the session.

OLD GROUPS CONTINUING FROM LAST SESSION

The membership of these groups is limited to those who participated in them last session; discussion will carry the subjects forward without going over the groung already discussed. These groups are as follows, the old group number being shown in brackets -

1 - Input/Output Methods and Media (3A)
2 - Administrative and Financial Considerations (1B)
3 - Impact of EDP on Management Control (4A)
4 - Stores Control and Material Costs (7A)
5 - General Accounting (10B)

MEMBERS' DIARY

OCTOBER 1957

14th (Manchester) - Regional Branch Meeting, College of Science and Technology, Sackville Street, Manchester 1, at 7 p.m.: Dr. B.V.Bowden, M.A., Ph.D., M.I.E.E.

21st - Senate House, University of London, Malet Street, London W.C.1., at 5.30 p.m.: Professor D.R.Hartree, F.R.S., "The Machine's-Eye View" (Dr. M.V.Wilkes, F.R.S., in the Chair).

23rd - Great Hall, Northampton College of Advanced Technology, St. John Street, London E.C.1., at 3 p.m.: Business Group Meeting, Discussion on 1956/57 Study Group Reports.

25th (Birmingham) - Regional Branch Meeting

NOVEMBER 1957

18th - Conference Room, County Hall, London, S.E.1., at 6.15 p.m.: A.J.Barnard, City Treasurer, Norwich Corporation, "The First Year with a Business Computer Installation" (A. E. Samuels, Chairman, Establishments Committee, L.C.C., in the Chair).

DECEMBER 1957

16th - Northampton College of Advanced Technology, St. John Street, London E.C.1., at 6.15 p.m.: Dr. S. Gill, Ferranti Ltd., "Parallel Programming: a Study of a New Technique in Digital Computer Programming" (Dr. M.V.Wilkes, F.R.S., in the Chair).

NEW GROUPS TO BE FORMED

The following new groups are to be formed, membership of them being open to all members, including those members of 'old' groups not wishing to rejoin them. Consideration of the main subject matter will be with special reference to the subsidiary points set down, but this does not preclude consideration of other and additional relevant matter.

6 - Administrative and Financial Considerations Affecting Computer Installations:

a. Problems of introducing the capabilities of computers to managememt personnel

b. Amortisation of computer equipment,

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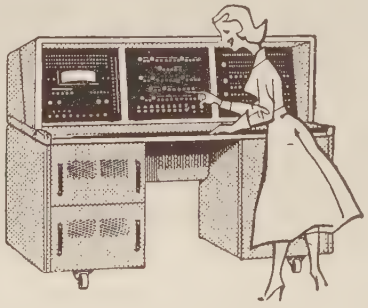
Electronic computers, like film stars, have been over-glamorised. Today a computer is the most highly-developed piece of office machinery, but it has no brain. It needs a human to direct it.

Electronic prodigy

Hec General-Purpose Computer solves simple or complex arithmetical problems at hundreds of operations a second. Instructions and initial data are entered from punched cards to its store, a memory in the form of a high-speed magnetic drum: and thereafter there is no human intervention.

Hec can discriminate

Hec can select the correct course of action through the instructions fed into it. Printed results can be confined, when you like, to exceptions from standards.

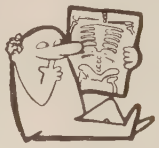


The console of the Hec Computer provides the operator with a check on what is going on and a means of communicating direct with the Computer

There is no aspect of purchasing, stores, production, costs, sales, distribution, market research, statistics and financial accounting with which it cannot cope at speed.

A nice balance

Yet Hec is easy to program and easy to control. It is not the largest computer there is, and far from the most expensive, but its memory, its speed, its calculating and printing capacity are *ideally balanced* to serve the needs of business today.



Study your own organisation

Responsible advice

Do you need a Hec Computer? The way to answer that question is first to study your own organisation and its needs. Then you would find it rewarding to co-opt the services of Hollerith methods and operations research men, accountants and technicians. Many business houses do this. There is no fee.

Education

If you decide to take a look at your business in the context of computers, short-term residential courses are available to you, or your executives, at the Hollerith Education Centre, Berkshire. These courses put techniques and applications at your fingertips, quickly.

Learn more about Hollerith electronics

THE BRITISH TABULATING MACHINE COMPANY LIMITED, 17 PARK LANE, LONDON, W.1

installation and programming costs, to allow for depreciation and obsolescence, and comparative advantages of rental and purchase.

c. Organisation and methods problems in computer installations, including methods of carrying out feasibility studies, problems of preparing for am installation and of running old installations in tandem during changeover period

7 - Comparative Data on Computers:

a. Considerations which dictate the size of store and the access speed required by users

b. Methods of organising data within the machine, so as to reduce the amount of expensive storage capacity required in the machine

c. What relationship, if any, can be established between cost per digit stored and access time?

8 - Comparative Programming Techniques:

a. Flow chart symbols

b. Programming strategy and techniques

c. Economical use of storage space

d. Comparison of methods of modifying instructions

e. Definition and development of automatic programming

9 - Input/Output - Current Developments:

a. The problems of preparing input media from original information

b. Bonus schemes and piece-work sustems for data preparation

c. Printing output systems

10 - Input/Output - Future Requirements:

a. Character recognition

b. Automatic transmission of data

c. Future improvements which appear to be desirable in the input/output field

11 - Impact of EDP on Management Control and Administrative Organisation:

a. Broad requirements of industry for computing techniques

b. Factors affecting organisations operating at widely dispersed points; what differences occur when the dispersed points are themselves large enough to support a computer installation?

c. Problems in dealing with management's requests for ad hoc information

d. Location of control of an EDP installation within an organsiation

12 - Training and Personnel Problems:

a. Methods of conducting general appreciation courses for employees of organisations embarking on electronic data processing

b. Problems involved in shift work, including shift maintenance

c. Training data preparation staff

d. Methods of familiarising programmers and operators with the operational requirements and system of business in general

e. Aptitude tests for the selection of staff

13 - Internal and External Audit:

a. Audit by program check

b. Audit by sampling

c. Audit checks on input data

d. Differentiation between internal and external audit, and their different functions relative to a computer installation

14 - Service Bureaux:

a. User's requirements

b. Methods of operation

c. Feasibility studies and programming of work to be done in service bureaux

15 - Business Statistics:

a. Market and opinion research

b. Sales analysis and economic statistics

c. Application of other mathematical techniques in business

16 - Industrial Statistics:

a. Industrial experimentation

b. Quality control

c. Application of other mathematical techniques in industry

17 - Payroll and Labour Costs:

18 - Stores Control and Material Costs:

19 - Sales Accounting:

20 - Production Control - Process Industries:

21 - Production Control - Engineering:

Under each of these headings, special reference is to be made to -

a. Definition of management's and other requirements

b. Indexing, numbering and referencing problems

c. Form and design of original data, and general documentation

d. Storage of permanent information

e. Specification of ideal methods of preparing input media from original data

f. Exchange of input media between organisations

22 - General and Cost Accounting:

With special reference to the integration of records for accounting purposes

BOOKS & ARTICLES NOTED

The following list of references to articles and books has been compiled primarily to help students, members of study groups, and others, to find material which may be of assistance to them.

The list includes references cited in the Short Bibliography (31 August 1956) and the Supplement (Information Bulletin No. 4) issued by the London Computer Group, and also those given in the last issue of THE COMPUTER BULLETIN.

Items marked $ have to be obtained from America and only a limited number of copies are available in this country.

Current reference lists will be published from time to time. Suggestions from members as to items to be included will be welcomed, and particularly references to members' own published books, articles, etc.

American Management Association - Electronic Data Processing in Industry: papers presented at 1955 conference, dealing with plans (AMA, 1955) $

- Establishing an Integrated Data-Processing System: Blueprint for a Company Program (AMA Special Report 11, 1956) $

- Pioneering in Electronic Data Processing: Company experience with electronic computers (AMA Special Report 9, 1956) $

Arris, W.J. - Electronics Assessed (Supplier, January 1957)

Association for Computing Machinery - Computers in Business and Industrial Systems: proceedings of Eastern Joint Computer Conference (with IRE and AIEE), Boston (ACM, New York) $

Beer, S. - The Office and Automation (Office Management, June 1957)

Berkeley, E.C. & Wainwright, A. - Computers: Their Operation and Applications (Chapman & Hall, 1956)

Berners-Lee, C.M. - Work Planning by Computer (New Scientist, 7 March 1957)

Booth, A.D. & Booth, K.H.V. - Automatic Digital Calculators (Butterworth, 1956)

Bowden, B.V. (Editor) - Faster Than Thought (Pitman, 1953)

Branholz, T.G.H. - The Design of the Pegasus Computer (Electronic Engineering, August & September 1957)

British Standards Institution - Glossary of Terms Relating to Automatic Digital Computers (BSI 2641, 1955)

Brockbank, A.J. - Automation and the Office, 5: economics of data processing (Process Control and Automation, February 1957)

Canning, R.G. - Electronic Data Processing for Business and Industry (Chapman & Hall, 1956)

Controllership Foundation - Electronics in Business: reference guide and bibliography (Controllership Foundation Inc., 1955 (& supplement 1956)) $

Dawkes, A.H. - An Approach to the Study of Electronic Data Processing Problems (O & M Bulletin, April 1957)

Department of Scientific & Industrial Research - Automation: report on technical trends and impact on management and labour (HMSO, 1956)

Evans, D.S. - The Digitizer: A High Accuracy Scale for Automatic Data Processing (British Communications & Electronics, June 1957)

Fry, T.C. - The Automatic Computer in Industry (Journal of the American Statistical Association, December 1956) $

Gray, T.J.Junr. - The New Frontiers: Electronic Equipment & Operations Research (N.A.C.A. Bulletin, February 1957)

Harris, W.B. - The Astonishing Computer (Fortune, June 1957)

- The Electronic Business (Fortune, April 1957)

Harvard University - Automatic Data Processing Conference: Proceedings (Bailey Bros & Swinfen, 1955)

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Jacobson, A.W. (Editor) - Training Personnel for the Computing Machine Field: proceedings of conference, 1954 (Wayne University Press, 1955) $

Johnson, C.L. - Analogue Computer Techniques (McGraw-Hill, 1956)

Jones, J.C. & Readshaw, D. - LACE (Luton Analogue Computing Engine: non-linear units used in a general purpose analogue computer, English Electric Guided Weapons Division (Electronic Engineering, July & August 1957)

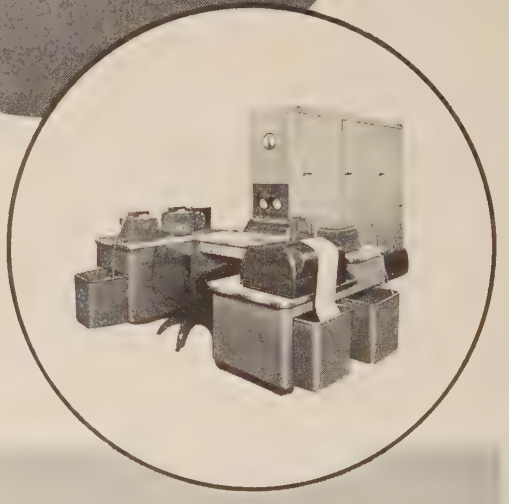
Jordan, G.H.S. - Electronic Data-Processing in the United States (Office Management, June 1957)

Kease, W.J. - Superseding the Manual System by Computers: A.E.C. (Organisation & Methods, March 1957)

This Computer Controls Our Production: case study at A.E.C. Ltd. (Organisation & Methods, February 1957)

MAGNETIC TAPE EQUIPMENT

for attachment to the FERRANTI PEGASUS COMPUTER



Ferranti Ltd. have developed magnetic tape equipment for attachment to the standard Pegasus Computer, thereby equipping the machine for a new range of scientific and administrative calculations.

For further information on this development, write:-

FERRANTI LTD

LONDON COMPUTER CENTRE: 21 PORTLAND PLACE, W.1. Telephone: LANgham 9211

Works: WEST GORTON · MANCHESTER 12

DC49

Kermack, G.S. - Controlling Machine Tools by Computer (Technology, June 1957)

Klingman, H.F. - Electronics in Business: case study in planning, Port of New York Authority (Controllership Foundation Inc., 1956) $

Kozmetsky, G. & Kircher, P. - Electronic Computers and Management Control (McGraw-Hill, 1956)

Lemke, B.C. - Business Applications of Computers: American appraisal of development in England and France (Accountant, 8 June 1957)

Limberg, H. - The Meaning of that Word Automation (The Office, February 1957)

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- Wage Accounting by Electronic Computer (HMSO, 1956)

Nodelman, H.M. & Smith, F.W. - Mathematics for Electronics, with Applications (McGraw-Hill, 1956)

Office Management Association - The Scope for Electronic Computers in the Office (OMA, 1955)

Oldfield, R.L. - Radio, Television and Basic Electronics: American 'text-book', primarily for students (Technical Press, 1957)

Pask, G. - Automatic Teaching Techniques: Solatron training machine (British Communications & Electronics, April 1957)

Shackel, B. - Human Engineering and Electronics (British Communications & Electronics, June 1957)

Smith, J.J. - The Management Approach to Electronic Digital Computers (MacDonald & Evans, 1957)

Spooner, P. - Getting Ready for a Computer: HEC 4 at Morgan Crucible Co Ltd (Business, June 1957)

Stockley, J.R. - An Electronic Computer Service: its practical application in the office (Office Management, March 1957)

Thomas, H.A. - Electronics in the Service of Mankind (Progress, Winter 1956/57)

Tizard, R.H. - Automatic Control and Computing in Industry: address given at National Cost Conference on 'Electronics in Industry', 31 May 1957 (Cost Accountant, July 1957)

- Electronic Computers and National Insurance (New Scientist, 9 May 1957)

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Wilkes, M.V. - Automatic Digital Computers (Methuen, 1956)

Worley, C.W., Franks, R.W.E. & Pink, J.F. - Process-Control Problems Yield to the Analogue Computer (Control Engineering, June 1957)

(unsigned) - An Electronic Data Processing System for Norwich (Electronic Engineering, June 1957)

- An Electronic Digital Computer: Metrovick 950 (Engineer, 22 March 1957)

- Computers, Analogue & Digital: basic principles, and comparison of respective usage and reliability (Nuclear Engineering, May 1957)

- Development in Electronic Reading Machines (British Communications & Electronics, May 1957)

- Electronic Accounting at Bristol Aircraft Ltd (British Communications & Electronics, May 1957)

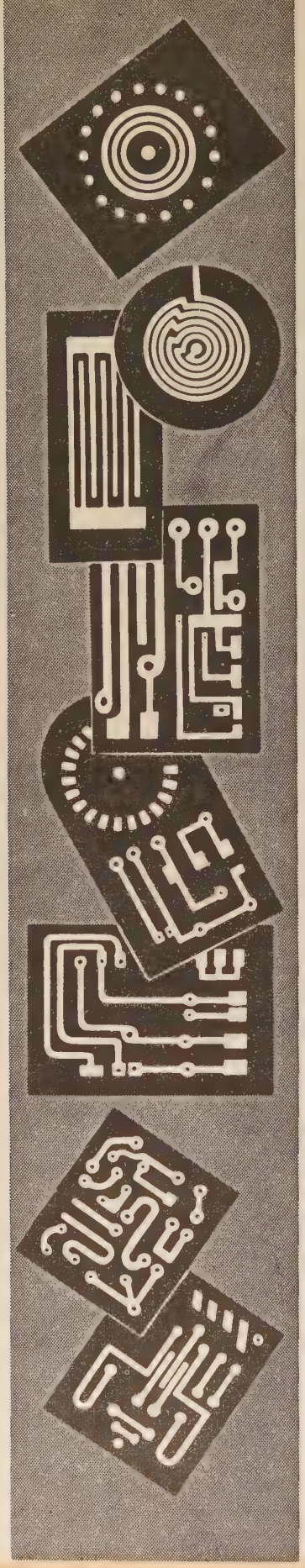
- Electronic Computers Index the Dead Sea Scrolls (Process Control & Automation, December 1956)

- Electronic Reading Automation, ERA: electronic reader capable of interpreting ordinary ink printed characters (Office Magazine, April 1957)

- The Metrovick 950 Digital Computer (British Communications & Electronics, May 1957)

- Smaller Memory Devices: brief note on aperture plate memory, RCA (Product Engineering)

PUBLISHED BY THE BRITISH COMPUTER SOCIETY, 29 BURY STREET, St. JAMES'S, LONDON, S.W.1.



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BOOK REVIEWS

DIGITAL COMPUTER PROGRAMMING - D.D.McCracken (John Wiley & Sons, Inc., New York; 1957; $7.75)

Since the publication of the book by Wilkes, Wheeler and Gill there has been an unfortunate delay in the appearance of up-to-date books on programming, and this book therefore meets a large and growing demand. It covers all the details of programming apart from the preliminary systems analysis or numerical analysis required to determine the overall method of approach to a problem. It demonstrates that the subject of programming can be presented in a general way without becoming involved in the incidental intricacies of actual computers and it also demonstrates the great wealth of material which has already accumulated on the subject of programming.

On the whole it covers the field very well, but there is a curious lack of any systematic survey and comparison of the various types of instruction code, whereas a considerable amount of space is devoted to a somewhat unnecessarily lengthy treatment of number systems, arithmetic processes, and scaling problems. Although the material is applicable to both scientific and commercial uses, the book is unfortunately written from the point of view of the scientific user and this may make it difficult for others to follow.

The Author's style is very readable but he has a tendency to introduce new ideas with little warning. It is perhaps remarkable that on reaching page 6 the Author has already described the essential features of computers, presented a simplified hypothetical computer and embarked upon a history of computing. According to the preface the book "is written for people with no previous knowledge of computing". The Reviewer would not recommend it to be read without some prior introduction to the subject; given this, however, it is a good survey of the many varied aspects of the programming art.

S.G.

AN INTRODUCTION TO AUTOMATIC DIGITAL COMPUTERS - R.K.Livesey (Cambridge University Press; 1957; 8s.6d.)

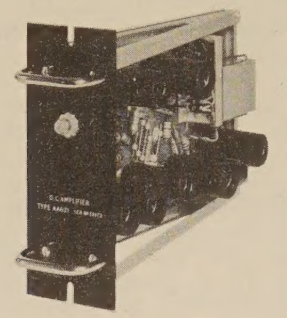
This elegant little volume in the Cambridge Engineering Series is written to convert those who, without any advanced mathematical training, believe that the use of computers is beyond their reach. The Author, who is lecturer in the Department of Engineering at Cambridge has based his book on a course of lectures first given at Manchester in 1954 and in the preface he acknowledges the assistance given by Professor D.R.Hartree during the preparation of the lectures for publication. He begins with a discussion of programming and gives an example of the mechanisation of a simple calculation. Input, Storage and Output of numbers are then discussed, followed by chapters on the organisation and simplification of programmes and solution of engineering problems.

This book is a useful introduction which the Reviewer recommends for the library of specialists, to be offered by way of explanation to those whom we seek to recruit and train as assistants, at one end, and to colleagues who want to know what we may do for them, at the other. By concentrating on programming the book has avoided any trace of the hysteria and mystery which characterises many American volumes of similar size. The decimal numbering of the paragraph headings will appeal to the careful reader.

H.W.G.G.

THE SOLATRON COMPUTER SERVICE

The Solatron computer service offers a range of computing elements from which analogue computers and simulators of many types may be built. The units are all designed to be used independently as required, but are based on a continuous machine unit of 100V and use identical supplies of + 300V. Available units include drift-corrected computer amplifiers, multipliers, linear computing units, power supplies and suitable mounting racks. The equipment incorporates the most advanced techniques and printed wiring is used wherever possible. Germanium junction rectifiers are used throughout in the power supplies.



DRIFT-CORRECTED COMPUTER AMPLIFIER AA621

This amplifier may be used for summing, sign reversing and integrating. It consists of a DC amplifier together with an auxiliary chopper type drift correcting amplifier.

Gain at DC	approx. 45×10^6	Effective grid current	approx. 1×10^{-10} amps
Gain in DC channel	approx. 30×10^3 falling to not less than 10^4 at 1,000 c/s	Noise at the output	less than 1 mV R.M.S.
Long term drift referred to the input	less than 100μV	Output voltage	+ 100V
		Output current	+ 10mA into 10kΩ

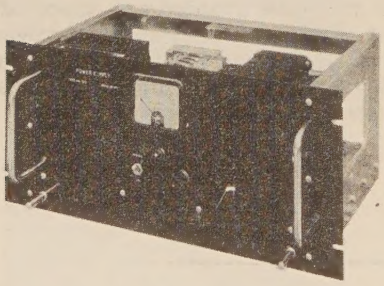
HEATER SUPPLY UNIT TS722

Each computer amplifier type AA621 is designed to have a separate heater supply in order to achieve its high performance and, to fulfil this requirement, the heater supply unit has been constructed. This consists of two transformers and a mains voltage selector panel, mounted in a frame identical in size to a computer amplifier.

Mains input . . 100V/220V + 20V 40-60 c/s Heater outputs . . 6 outputs each of 6.3V at 2A

AMPLIFIER MOUNTING UNIT TX791

This frame is intended to house five computer amplifiers and a heater supply unit. Its dimensions are such that it can be fitted into a standard 19" Post Office Rack. The connection sockets at the rear of the mounting unit are wired so that the complete assembly may be very rapidly installed into an equipment. The heater unit outlets are distributed to each amplifier, the spare one being connected to a connector strip for remote use. H.T. points are commoned and, together with the main input to the Heater unit, are also connected to connector strips. The amplifier output and summing junction are each connected to two banana plug sockets for simple patching and single connections are provided for the test points and earth, to simplify setting up of the individual amplifiers.



COMPUTER POWER SUPPLY AS755

These power supplies provide an output of 300V at 500mA and, as either the positive or negative line may be earthed, two such power units are normally suitable to provide the H.T. current required by 20 computer amplifiers.

DC output	300V at 500mA	Ripple	approx. 0.5mV
DC resistance	less than 0.25 ohms	Permissible mains variation	+7%
AC resistance 20 c/s-200 Kc/s	less than 0.5 ohms	Mains input	100V/220V + 20V 40-60 c/s
Stabilisation ratio	approx. 300 : 1		

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THE SOLATRON ELECTRONIC GROUP LTD.
THAMES DITTON, SURREY
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COURSE REPORT

ELECTRONIC DATA PROCESSING IN INDUSTRY AND COMMERCE

COURSES AT DUNDEE

Two courses were held at Dundee Technical College during August, dealing with the application of electronic data processing to business problems. With an attendance of seventy-eight, drawn from a wide range of private, nationalised and state industrial and commercial undertakings, these complementary courses had the benefit of the teaching of Professor Robert H. Gregory, Professor of Accounting at Massachusetts Institute of Technology, who was visiting Europe during the summer. He also made available to the courses a number of papers written by himself and his colleagues at M.I.T.. Dr. Stanley Gill, Head of the Computing Research Group of Ferranti Ltd., was associated with the first of the two courses, and technical assistance was also given by Ferranti Ltd., Powers-Samas Ltd. and National Cash Register-Elliot Bros. Ltd.

The main objective of the first course, "Electronic Computers and Business Problems", were to indicate what a computer is, how it can be instructed to carry out computations and the areas in which it can operate. Discussions were based on a "paper" computer, SIMAC (Simplified Automatic Computer), to simulate the major characteristics of a typical electronic digital computer.

Members of this course were also introduced to the way in which statistics can be applied to computers and to the idea that linear programming may be used to provide solutions to problems of forecasting and production planning; problems which at present are being handled in an incomplete and expensive manner, either because the data is lacking or because it is not available sufficiently quickly. Methods of input and output were considered, with particular reference to magnetic tape and film.

The Course concluded with discussion on the economics of computers, not only in relation to the cost of operation but also dealing with the value of information in regard to age and cost. Professor Gregory pointed out that it is possible to plot a relationship between the age of information and its value to management. It is not always vital to receive information "hot off the press", and managements, when considering the usefulness of a computer, should examine carefully the speed with which any given piece of information is required. Much stress is being laid at the moment on speedy access to information stored in the computer, but this is an extremely costly luxury unless high speed is vital.

The second course, "Business Management and Electronic Data Processing", assumed attendance at the first course or equivalent knowledge; the main purpose was to examine some actual applications of computers to business situations, such as payroll, inventory control, production planning and invoicing.

The course also investigated the way in which the structure of an organisation is affected when a computer is installed. There are, for example, the obvious problems of training, retraining, and redeployment of staff. The computer's impact, however, is likely to be felt more deeply. If maximum results are to be obtained from the computer, with its possibilities for integrated data processing, a searching review of the organisation's managerial and supervisory structure must be undertaken. Such a review is likely to result in the redefinition of functions, the merging, or perhaps the expansion, of departments. The activities of the organisation will tend, and this must be fully appreciated, to centre round the computer.

This conclusion is probably the most important one drawn from the course. The installation of a computer is likely to alter radically the way in which the firm conducts its affairs. The computer is not an accounting machine writ large, it is one of the major contributions of the 20th century to the industrial revolution and consequently is likely to have a profound effect on the manner in which business is organised and conducted.

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